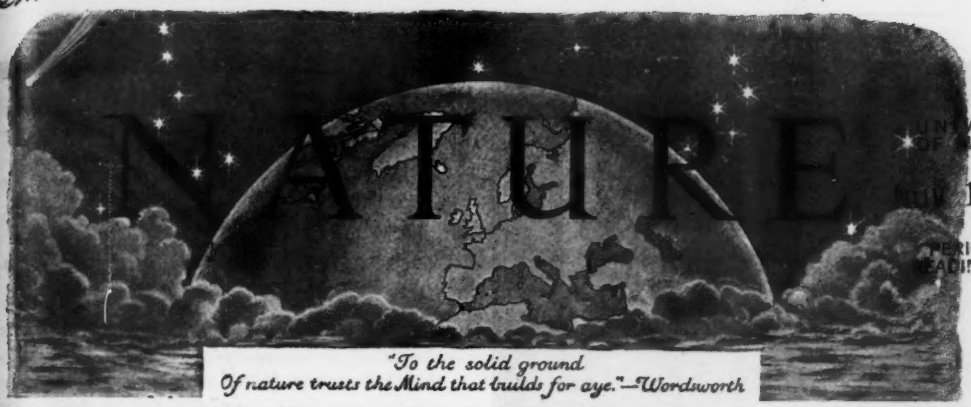

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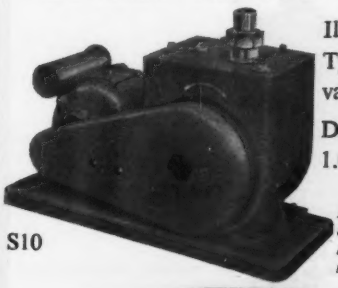

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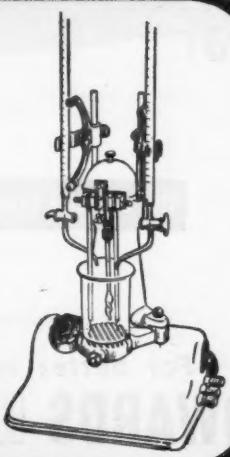

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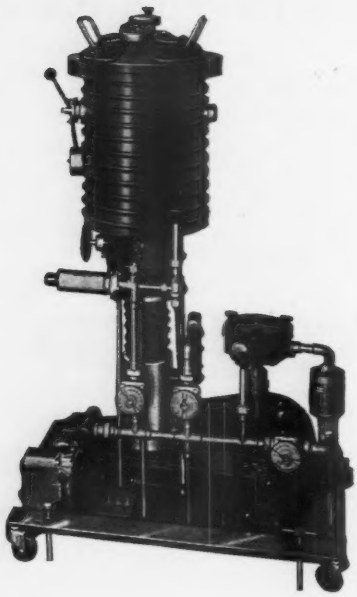

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NATURE

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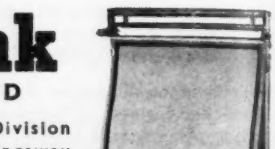

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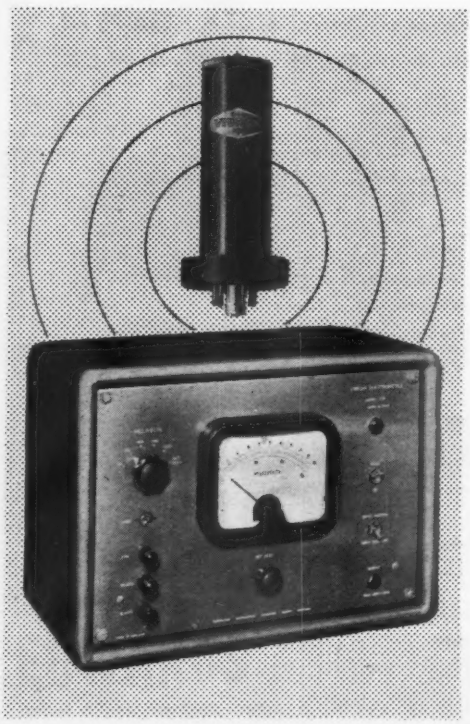

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DEPLOYMENT OF SCIENTIFIC AND TECHNICAL MAN-POWER

JUST over ten years ago, the Barlow Committee presented its report on scientific man-power in Britain, recommending that the nation should double its present output of scientists to give roughly 5,000 newly qualified scientists per annum at the earliest possible moment. The Committee's calculations visualized a demand for some 90,000 scientists by 1955, and it is common knowledge that the universities in actual fact doubled their output of scientists and technologists by 1950, though in 1956 the shortage of scientists and technologists continued unabated and, despite some unemployment among particular categories of scientists, fears as to possible over-production of scientists and engineers have been completely dispelled by events.

The Barlow Committee made no attempt to assess the demand for particular categories of scientists, recognizing that to do so would involve a formidable statistical inquiry which, if attempted, would seriously delay the presentation of its report. The then newly formed Advisory Council for Scientific Policy was charged with the responsibility "to advise the Lord President of the Council in the exercise of his responsibility for the formulation and execution of Government and scientific policy", and has in particular been asked to make recommendations about "the arrangements for securing an adequate flow of scientific man-power to meet the needs both of Government and industry". The Barlow Committee thus wisely left for later attention the determination of the demand for each particular type of scientist, and in December 1950 the Advisory Council appointed a Committee on Scientific Man-power under the chairmanship of Prof. (now Sir Solly) Zuckerman, "to study the future needs of scientific and technological manpower for employment both at home and abroad and to report to the Council from time to time".

A report from this Committee was issued as the Advisory Council's fifth annual report in May 1952, and this was followed last November by a report on the recruitment of scientists and engineers by the engineering industry. The report on scientific and engineering man-power in Great Britain which has now come jointly from the Advisory Council and the Ministry of Labour and National Service (see p. 887 of this issue of *Nature*) embodies the results of a further inquiry by this Committee and of one initiated by the Ministry of Labour which go some way towards meeting this need for further statistical detail. Admittedly there is a certain amount of conjecture and the Committee on Scientific Man-power is probably right in suggesting that it is impossible to predict the rates at which the annual flow of newly qualified people and of the total stock of scientists and engineers in employment are likely to increase, nor does it deny that there are still gaps in our knowledge as to the existing situation. The figures for scientists and engineers in manufacturing industry may still be subject to some margin of error. The exclusion of the small firm, with fewer than a hundred employees, may not seriously affect the present estimate, even although such small firms constitute by far the majority; but it could seriously affect the potential demand if Britain is to maintain its competitive position in the world's markets.

Again, the Committee points out that we have no clear idea of what proportion of science graduates take up work in their respective fields in Great Britain. It also notes that its figures for the employment of scientists in the public sector of the economy, including teaching, reflect current policy, which may well differ from future policy; nor is the assumption sacrosanct that, on the average, the number of scientists and engineers employed in industry will increase in proportion to increases in output. None the less, it believes that this view is better than any other on which it could base its calculations, and, whatever the weaknesses in its interpretation of future needs, the assessment in the present report has the undoubted merit of starting with a more accurate picture of the employment of scientists and engineers to-day.

In place of the estimated demand in 1955 of 90,000 and the 64,000 qualified scientists which were considered as likely to be available on the plans then existing (which provided for some 5,000 additional scientists and technologists annually), the present inquiry by the Ministry of Labour puts the number of scientists and engineers employed in Great Britain early in 1956 as just short of 120,000, of whom some 51,000 are scientists and just short of 69,000 engineers. It is estimated that there are a further 5,000 scientists and 10,000 engineers in fields not covered by the inquiry. While both reports use the term 'qualified scientist' in the same sense, the Barlow report made no estimate for engineering and related technologists, which before the War accounted for about 40 per cent as many engineering students as the pure science schools. It would appear, however, to include those qualified in agricultural or veterinary science, who are excluded from the present report, and also to include those working in the Oversea Civil Service, who are likewise excluded from the present report.

The Committee on Scientific Man-power is well aware of the discrepancies between the present estimate and that of the Barlow Report and other earlier inquiries, and it does not suggest that they are entirely accounted for by the omission from the present inquiry of scientists working abroad. Earlier inquiries, it is suggested, may have made insufficient allowance for women science graduates who are no longer in employment; but the greater part of the difference is attributed to science graduates who have taken employment in other fields—for example, men with degrees in physics now classified as engineers, mathematicians now working as actuaries, or men and women with qualifications in science now in employment in which such qualifications are not demanded. The number of qualified engineers revealed by the inquiry, however, agrees reasonably well with other calculations based upon the number

of past awards of university degrees and corresponding qualifications in the engineering sciences.

Such discrepancies are of minor importance in relation to the actual number of scientists and engineers working in Great Britain. The major interest of the report is in respect of the assessment of the probable future demand for scientific and engineering man-power. For the first time, a goal is set for the expansion of technological education and of scientific studies at the universities, based on a reasoned estimate of the future demands in Britain for scientists and technologists. Even without taking account of overseas demands, of certain relatively small categories such as agricultural and veterinary scientists and ignoring the problematic but possibly considerable and important demands of the small firms and, presumably, the requirements of management and administration for men qualified in science as well as in administration, the report is emphatic that the output of 10,000 scientists and technologists a year which the universities had achieved in four years from the appearance of the Barlow Report is quite inadequate. To come within sight of meeting the minimum needs of Britain's economy, we must aim at doubling that figure and achieve an annual output of roughly 20,000 by 1970.

In this figure, the Committee does not differentiate between scientists and engineers, and accordingly the estimate is not affected by the transference in employment from one category to another. It has, however, included an allowance of 25 per cent for overseas students, emigration, etc., as well as for the continuance of some measure of shortage. This is wise, for there are certain respects in which Britain's economic strength lies in its ability to provide trained man-power, as, for example, under the Colombo Plan and the Expanded Technical Assistance Programme, or again in relation to nuclear energy. Any realistic appraisal of Britain's needs for trained scientific and technical man-power cannot be limited to those employed in the country itself, but must take some account of overseas requirements and perhaps especially for the under-developed areas.

Before examining the distribution of scientific and technological man-power in relation to the future demand, there is one point to be noted which receives little attention in the present report. The Committee does not doubt that sufficient talented boys and girls will be available, if they choose to take up careers in science and engineering, to be trained at the rates which it recommends should now form the basis of national policy. It is not for the Committee, but for the University Grants Committee and the various education departments to consider how these probable demands for graduates in pure and applied science are to be met; but it will be noted that the Committee recommends that, provided there is no lowering of standards, the universities should attempt to provide as much as possible of the necessary expansion. In its view, there is little risk that the greatest possible combined efforts of the universities and technical colleges will result in any over-production of professional scientists and engineers during the 1960's.

The nation's demand for trained man-power depends in part on the way in which that man-power is used. That is to say, it depends on that man-power being employed in occupations in which scientific or technological training can be put to effective and efficient use. The efficient use of trained man-power requires not only the provision of necessary equipment and appropriate conditions of work, but equally the provision of the appropriate ancillary technicians and facilities. If the research worker, for example, is not provided with the appropriate assistance, his time may be wasted on occupations for which much less highly trained and skilled persons could be used and which he himself performs less efficiently.

We cannot, in fact, separate consideration of the probable demand for scientific and technological man-power from that of the demand for technicians; and a corollary of the present survey is, in the first place, some attempt to assess the efficiency with which scientific man-power in Britain is at present being used. It might well be found that if we used our existing resources of highly trained man-power more efficiently, the existing shortage would be less acute; and that Britain's needs could be met by some less expensive means than doubling the present number of scientists and engineers. Changes such as those which have recently been discussed in connexion with what is commonly described as automation have pointed in this direction, and the disappearing differential in salary or wage between the technician and scientist or technologist can have consequences that make it essential for closer consideration to be given to this aspect of our needs for trained man-power.

The expansion of technical education in Britain cannot be planned reasonably without some estimate of the nation's need for technicians, and here again it cannot be too strongly emphasized that any attempt to force the expansion of the technical colleges to provide professional engineers and technologists which hinders their primary and essential function of providing technicians is detrimental to the nation's interests, and may well involve waste of highly trained man-power. The Committee on Scientific Man-power does not, however, consider the question whether we have sufficient talent to provide simultaneously this doubled output of scientists and engineers, and also the output of technicians necessary to sustain that number efficiently. The present output of technicians might well require to be trebled or more, and there was no suggestion in the recent White Paper on Technical Education that the implications are appreciated by the Minister.

The picture of the present distribution of scientists and engineers in Great Britain which is given in this report has other implications in regard to the expansion of the present output. The report assumes a 100 per cent increase in the requirements of the universities over the next ten years; but its assessment of requirements for teaching in secondary schools makes no provision for any further concentration on scientific subjects, or for any improvement in existing staffing ratios. It suggests that an addi-

tional 4,000 science graduates would be a reasonable allowance for the latter, and this could well have an important bearing on attracting the increased number of boys and girls to take up careers in science and technology, as well as in raising standards of training.

The bearing of the quality of teaching on the supply of graduates in science and engineering appears to have received relatively little attention, and the wide variation in the proportion of those who take up teaching—in schools, colleges and universities—between different categories of scientists and engineers may not be without significance. Whereas only 5,643 out of 20,692 chemists and 4,751 out of 10,484 physicists are to be found in education, 442 out of 894 geologists, 3,381 out of 4,838 biologists and 9,302 out of 11,482 mathematicians are so occupied. Out of a grand total of 68,456 engineers, however, only 2,429 are teaching, and of these 1,712 (out of 19,533) are electrical engineers. Even when all due allowance is made for the concentration of those teaching engineering, for example, in the universities where the numerical requirements are much smaller than in the schools, and for the possibility of part-time seconding of staff from industry for teaching in the technical colleges, there may be some room for inquiry here if we are to overcome the reluctance of some parents and school authorities to encourage their pupils to enter on scientific or technical careers.

Here, of course, there operates too the differential factor in regard to salaries, and it should not be assumed too readily that the expansion recommended in this report will necessarily provide Britain with the distribution of trained man-power that is desirable unless appropriate action is taken to encourage the desired distribution.

The report estimates that, of 48,829 qualified scientists employed in manufacturing industry, 21,734 are engaged in research and development; while of 17,078 employed in the nationalized industries, only 2,526 are so engaged, of whom 1,706 are with the Atomic Energy Authority. Of the 13,850 employed by the central government, 2,350 are employed by the research departments, that is to say, the Department of Scientific and Industrial Research, the Agricultural Research Council, the Medical Research Council and the Nature Conservancy; but of the 7,600 employed by the defence departments, a number will obviously also be engaged on research. There is no indication of what proportion of the 3,250 scientists and engineers employed by the universities are engaged on research; of the total of 71,122 scientists and engineers employed in industry, only 1,397 are employed by the research associations.

There thus appears to be no firm basis for the belief that the research associations take an undue proportion of Britain's scientific and technical man-power. Nor does the report substantiate the view that, so far as scientists and engineers are concerned, an excessive proportion of trained man-power is employed on defence. Moreover, when we make an appropriate allowance for those of the 21,734 scientists and engineers engaged in research and development work in industry who are occupied on work that is development or merely the systematic exploration of a known field by recognized techniques rather than fundamental inquiry, it is clear that the proportion of men trained in fundamental investigation by industry annually is relatively small compared with those trained in the scientific outlook. This also might well bear on the character of the training given in the universities and colleges of technology, and any expansion of the order recommended in this report can scarcely fail to take account of the possibility that methods of training and particularly of the practice of teaching research may merit re-examination. Otherwise there could well be waste of man-power in teaching as well as ineffective teaching.

Some of these fears find expression in the report on the recruitment of scientists and engineers by the engineering industry, and although the Committee on Scientific Man-power does not here revert to them, it may be taken that they will not be overlooked. If we are to attract this higher proportion of Britain's youthful talent into the channels that this report recommends, we must take every care to see that the training given is appropriate to its purpose, and that the talent so trained is wisely and efficiently used and, so far as possible, where it will best serve the national need. The report establishes a reasonable case for the projected expansion of technological education in Britain and for the expansion which the universities are expected shortly to announce for the forthcoming quinquennium. It can scarcely fail to raise fresh doubts, however, as to the adequacy and even the soundness of the Minister of Education's plans for the expansion of technical education, or as to the extent to which the Government has really grasped the implications of the present situation and what is involved in the efficient use of trained man-power. At least, however, the report provides the starting point for a fresh assessment of the way in which the expansion of technological and technical education should be planned and executed, and for a further attempt to convince the Government of the dependence of the effective use of Britain's resources of scientific and technical man-power on those accessories such as the National Science Centre, the National Reference Library of Science and Technology and the National Science Lending Library, which the Advisory Council on Scientific Policy has hitherto ineffectively urged upon it.

BRITISH GRADUATES AND THEIR EMPLOYMENT

Graduate Employment

A Sample Survey. Pp. xiv + 300. (London: Political and Economic Planning, and George Allen and Unwin, Ltd., 1956.) 30*s*.

STATISTICS of the output of coal, one of the few natural resources of Britain, would have little value if unassociated with figures of distribution and demand. The contrast between the knowledge we have about this vital national asset and our ignorance about the fate of the thousands of men and women who graduate year after year from British univer-

sities, but who are also in very short supply, is the point of departure of an inquiry by Political and Economic Planning into graduate employment. This sets out "to discover the jobs to which graduates leaving universities in Great Britain are going and the influences that determine their choice of employment; and to relate this information to such factors as age, sex, parental occupation, university attended, course taken and degree obtained".

The desirability of information of this kind has been recognized ever since 1946, when the Barlow Committee's Report on Scientific Man-power sowed the seeds for what has become a widespread concern about Britain's chronic shortage of scientists and engineers; about the deleterious effect of the shortage on our national position; about the scarcity of teachers of science and mathematics; and about the failure of our educational system to weave into the pattern of general culture an appreciation of scientific matters, and more important, an awareness of the incredible speed with which their influence over human affairs is growing.

The difficulty has always been, and still remains, that it is far simpler to find out what human beings do with the things they produce, than to discover how they dispose of themselves. We know that there is a shortage of scientific man-power. But we have few precise ideas about the present stock and distribution of scientists and engineers in employment as such; about the extent of the shortage in different fields of employment; about its probable duration in the light of steps that have been taken to overcome present difficulties; and about the fate of our science and engineering graduates. Until the recent inquiry instigated by the Ministry of Labour and National Service [see this issue of *Nature*, p. 887], we have had to rely on actuarial analyses of the numbers of graduates turned out in past years to get any idea about the first of these questions. So far as the last is concerned, we have had to accept the fact that it would be extremely difficult for the universities to keep a record of the subsequent careers of the men and women who graduate from them.

Just how difficult emerges from the P.E.P. inquiry, which began in 1953 under the sponsorship of a Joint Committee of the Department of Scientific and Industrial Research and the Medical Research Council, with the aid of U.S. Counterpart Funds. Because of the immense labour involved, the study was confined to a sample of one in two of the male graduates of 1950 in arts, science and technology from English, Welsh and Scottish Universities. Nearly seven thousand questionnaires were sent out; replies were received from about two in every three. For all practical purposes, therefore, this means that P.E.P. was unable to find out anything about the whereabouts of one-third of all graduates as little as four years after they had left their universities. Of the men who replied, nearly two-thirds came from grammar schools or their Scottish equivalents. An even higher proportion received some form of public financial help when at the universities. Just over half read for an arts degree; 28 per cent for a science degree; and 20 per cent for a technology degree. On graduating, the technologists tended to go straight into employment, whereas large numbers of arts men and scientists tended to stay on for further study. More than a third of those who obtained first-class degrees stayed on for at least two years; and—most interesting—half the sample started their university careers without any clear idea about what they were going to do afterwards; while two in three held that the decisions that they finally took about their future work were reached entirely independently, without outside influence. In the event, 30 per cent went into industry and 23 per cent into teaching.

These are only a few of the interesting facts that emerge from the P.E.P. study. But, as the volume itself points out, it is necessary to remember that the conclusions reached relate only to a short period in the history of one batch of graduates, and to a year, 1950, which must have included many men who had been on active service during the Second World War. The survey is, therefore, a cross-section of a particular piece of history. Because of the immense labour involved, it also had to be an incomplete cross-section. For example, the women graduates of 1950 were not included. On the other hand, the value of the work is greater than just the straightforward, even if limited, facts that it discloses. For example, it throws up this critical question. If half the people going to the universities of Britain have no clear idea about what they wish to do afterwards, and believe they are uninfluenced in their decisions as to which posts to take up after graduation, what is the value of all the propaganda that has been going on about Britain's need for more scientists and engineers? Or does its apparent ineffectiveness relate only to people who graduated in 1950? Equally important, how quickly will the market mechanism, in the form of higher salaries paid to engineers and scientists, operate against the social conventions which in some numerically small but influential corners have for so long placed a higher prestige value on a university education in the arts? But perhaps the most important issue which P.E.P.'s valuable study underlines is the need for regular, even if not detailed, returns about graduate employment in Britain. There can be little doubt that if it were possible to arrange for a steady flow of such information, the task of those who are concerned with ministering to the growth of our universities, technical and other training colleges and schools, would be greatly eased. S. Zuckerman

INTERNATIONAL ENCYCLOPÆDIA OF UNIFIED SCIENCE

International Encyclopedia of Unified Science
Edited by Otto Neurath, Rudolf Carnap and Charles Morris. (Combined edition.) Vol. 1, Part 1 (Nos. 1–5): Pp. ix+1–340. Vol. 1, Part 2 (Nos. 6–10): Pp. iv+341–760. (Chicago, Ill.: University of Chicago Press; London: Cambridge University Press, 1955.) 41*s*. 6*d*. net each part.

COMMENCED in 1938, the introductory material of the "International Encyclopedia of Unified Science" has been published at intervals by the University of Chicago and is now issued in a combined edition as Vol. 1, which is divided into two considerable parts. Each of the two parts contains five sections of seventy or eighty pages each. The idea from which the work developed was that of Otto Neurath, of Isotype fame, who conceived a scheme which should continue the work of the French "Encyclopédie" of the eighteenth century. Unified science became historically the subject of this "Encyclopedia" as a result of the efforts of the Unity of Science movement, which includes

scientists and persons interested in science who are conscious of the importance of a universal scientific attitude.

The new version of the idea of unified science is created by the confluence of several intellectual currents. Empirical work of scientists was often antagonistic to the logical constructions of *a priori* rationalism bred by philosophico-religious systems; therefore 'empiricalization' and 'logicalization' were considered mostly to be in opposition: the two have now become synthesized for the first time in history. Certain empiricists began to appreciate logical analysis and construction as universal scientific aids; other thinkers, especially interested in the historical importance of scientific imagination, stress their opposition to all kinds of *a priori* reasoning and demand empirical tests for all their theories. The terms 'logical empiricism' and 'empirical rationalism' express very well this new type of synthesis. The terms 'unified science' and 'unity of science' are becoming more and more widespread in usage. The annual congresses devoted to the unity of science held first at Charles University in Prague in 1934 were disturbed by the Second World War, and a number of the leading members have since died, but the movement continues. Physicists are familiar with co-operation in the field of physics, and biologists in the field of biology: the movement for unified science stresses the need for further co-operation—physicists with biologists, biologists with sociologists, and other specialists with logicians and mathematicians.

The "International Encyclopedia of Unified Science" endeavours to show how various scientific activities such as observation, experiment and reasoning can be synthesized and how all these together help to evolve unified science. The busy research worker may not find himself in sympathy with some of the painstaking accounts of the logical and philosophical foundations on which his subject rests; but, nonetheless, they are of prime importance. The flowing tide of nineteenth-century science was too hurried to regard the work of J. S. Mill.

The editors of the present works have been fortunate in the choice of authors. Otto Neurath opens the introductory monograph with an essay on unified science as encyclopædic integration; John Dewey discusses unity of science as a social problem; Rudolf Carnap analyses the logical foundations of the unity of science; and Charles W. Morris, in his essay on empiricism, attempts to formulate a general framework for the encyclopædic enterprise as a whole. There are two short papers: by Niels Bohr on analysis and synthesis in science, and by Bertrand Russell on the importance of logical form.

In the second section, Charles W. Morris outlines the field of the theory of signs, showing the place of this within the unity of science movement. He also examines in turn the main sub-divisions of semiotic (theory of signs), syntactics, semantics and pragmatics. This is followed by Rudolf Carnap's study of the foundations of logic and mathematics, which considers the nature and interpretation of a calculus and calculi and their application in empirical science.

Leonard Bloomfield's monograph is concerned with the nature of linguistics as a science, the devices of natural languages used to attain precision, the special characteristics of the language of science, the place of linguistics in the scheme of science, and the relation of linguistics to logic and mathematics. Victor F. Lenzen deals with the various procedures of empirical science, techniques of observation and the various procedures of systematization. Part 2 has five sections: the principles of the theory of probability, by Ernest Nagel; the foundations of physics, by Philipp Frank; cosmology, by E. Finlay-Freundlich; the foundations of biology, by Felix Mainx; and finally, the conceptual framework of psychology, by Egon Brunswik.

The seven hundred and sixty pages of the two parts of Vol. 1 are not all easy reading; but it would be difficult to think of a more convenient and concentrated account of what must be regarded as a necessary foundation for any superstructure of specialized scientific knowledge, system of techniques or principles. Much of the teaching of science to-day gives us an impression of the branches and leaves of the tree of science but little of its trunk and roots.

W. L. SUMNER

LUDWIG MOND

The Life of Ludwig Mond

By J. M. Cohen. Pp. xv+295+17 plates. (London: Methuen and Co., Ltd., 1956.) 22*s*. 6*d*. net.

RARELY does the biography of a father follow that of his son by well-nigh a generation, and when that happens it is not too easy to avoid a certain amount of repetition. Mr. J. M. Cohen's book differs profoundly from Hector Bolitho's life of "Alfred Mond: First Baron Melchett" (1933), though in narrative and anecdote he has drawn to some extent on the earlier part of Bolitho's book, particularly in respect of Ludwig Mond's early days in the chemical industry, the venture at Winnington and the early association of his two sons with Winnington. Only at such points do the two books touch, however; there is the stamp of Mr. Cohen's own personality on the successive chapters in which he depicts the education of a scientist, his apprenticeship in the infant chemical industry, the conflict of interests which finally issued in Mond's settling in Britain and not in Holland and the founding and growth of the Winnington works. There emerges a vivid and fascinating picture of a great industrialist which can be read with as much ease and pleasure by the layman as by the technologist.

It is a portrait which is highly pertinent for these days when men like Sir Henry Tizard are wondering whether British manufacturers are becoming less enterprising. Here is told a story in which enterprise is writ large and in which, too, myths often sedulously fostered about those who put capital as well as brains and judgment into manufacturing ventures are dealt some shrewd blows. There stands out the determination and perseverance of Ludwig Mond, his versatility and inventive genius, his devotion to research and his untiring urge for conservation and the recovery or avoidance of waste, as well as something of his ideas on industrial relations, in which he was a pioneer. Mr. A. S. Irvine contributes a series of technical appendixes which give the background of Mond's technical achievements and review the decline and fall of the Leblanc soda system, and also a postscript which takes, very briefly, the story of the Mond connexion with the chemical industry to its termination and attempts a brief appreciation of his achievements.

Yet while the personality of 'the old doctor', as he was called at Winnington, emerges vividly in these

pages and his achievements are mentioned, the book does not really measure his technological stature. In that respect, indeed, it falls short of Mr. J. I. Watts's admirable obituary notice in the *Transactions of the Chemical Society*. Nowhere is the reader given the clear appraisal of Mond's outstanding achievements that the chemist might expect and the layman needs. Nor does the book display at all adequately the vigour and range of Mond's own thought and philosophy, much of which is highly relevant to our own times.

This is the more unfortunate in that the book contains no list of Mond's own writings or addresses, nor any list of his nearly fifty British patent specifications. Nor is there more than incidental reference to such important contributions as the founding and development of the Society of Chemical Industry, the steady support he gave to the improvement of the Royal Society's catalogue of scientific papers and afterwards to the cataloguing of international scientific literature, and the endowment of the Davy–Faraday Laboratory at the Royal Institution, London. Failing to relate Mond's outlook and thought to our current problems, the book lacks something of the inspiration it could well have had for the younger generation, and the absence of references detracts a little from its value as a contribution to industrial history.

For all its merits, the book is not the book that H. E. Armstrong would have given us had he lived to complete the task to which he set his hand. Into whatever by-ways Armstrong might have strayed, we may be sure that he would have fully displayed the vigour of his friend's mind and the relevance to our times, for example, of Mond's ideas on the training of the scientist when he pressed the claims of a thorough grounding in theoretical science, even to the extent of disputing the value of teaching applied science, or again of his ideas as to the possibility of a science of invention. It is in such addresses as those which Mond gave at the opening of the Schorlemmer Laboratory in Manchester or as president of the Society of Chemical Industry, when he argued that the steady methodical investigation of natural phenomena is the father of industrial progress, that we find the industrial philosophy which was one of Mond's most stimulating characteristics. The achievements are displayed in Mr. Cohen's book, but something more is wanted to bring the reader easily into contact with the vigour and stimulus of Mond's thought.

R. Brightman

FRENCH ATLAS OF THE FUNGI

Nouvel Atlas des Champignons

Par Henri Romagnesi. Tome 1. (Publié sous les auspices de la Société Mycologique de France.) Pp. 96+79 planches. (Paris: Bordas, 1956.) 5550 francs.

IT is so seldom nowadays that a reviewer is able to give whole-hearted praise to plates, paper, type and binding of a scientific book that it seems proper to make immediate comment on it. Moreover, the author, Henri Romagnesi, is one of the foremost, as he is one of the most active, of the excellent modern school of French mycologists.

The present volume is the first of three, and the plates figure species of *Lactarius*, *Russula*, *Lepiota*, *Psalliota*, *Amanita* and all genera with coloured spores. The second volume, which is to be published at the end of the year, will include agarics with white spores, the remainder of the Basidiomycetes, morels and other large Discomycetes. The final volume will be of rarer species and those of which no good figure has been published, and, presumably, will not be long delayed.

The introduction, eighty pages in length, gives a general summary of the nature of fungi and their classification; structure; physiology; reproduction; poisonous fungi; edible fungi (with recipes for cooking); and principal genera and sub-genera. Although this is a popular book, it is not written exclusively for beginners but is a thoroughly up-to-date, though concise, account of the matters treated therein, with a view to a wider appeal. Certainly, many who profess and call themselves mycologists will find much for thought and, indeed, not a little to learn here. (It is news to me that the cultivation of mushrooms "en cousine" is still sometimes practised in hotels in Britain.) There are twenty-two text-figures, several of them detailed and occupying a whole page.

As is perhaps to be expected in a French work, a good deal of space is devoted to classification. There is a general outline in the first chapter, and the final thirty-four pages provide details. A series of dichotomous keys gives a clear idea of the macroscopic characters useful in differentiating between different genera and sub-genera of the Agaricales. The remaining Basidiomycetes are treated in somewhat less detail. The families of Discomycetes and Tuberales are also keyed.

The seventy-nine plates depict a little more than a hundred species and varieties. They are reproduced lithographically in eight to twelve colours from originals in the collections of the French Mycological Society, and most of them are by Dr. J. Chenantais. Unfortunately, the drawings which he bequeathed to the Society did not include all the species needed for this work, so those of others were added, mostly by Col. A. Lacaze. In my view, those of Chenantais are among the best that have ever been published, rivalling in beauty and in exactness those of E. Boudier's "Icones Mycologicae", though without microscopic details.

A page of description accompanies each plate. The descriptions are clear and include all the microscopic details necessary for exact and intelligent identification. The notes on habitats are full and often contain interesting facts such as only one with Romagnesi's vast experience as a collector could supply: those on "importance pratique" are concerned solely with gastronomy.

Where a species is likely to be confused with one or more others, the contrasting characters are listed in parallel columns. Only experience shows what strange confusions sometimes arise: some of those given I have not encountered. It is only by contrasting the characters one by one that misconceptions can be straightened out and confidence gained.

Most of the fungi figured are common ones, in Britain as well as in France. There are, however, a number of varieties, particularly of poisonous species, which are rarer—some of these with no previously published illustrations.

Everyone connected with the publication of this excellent work is to be warmly congratulated.

John Ramsbottom

THE BATTLE OF THE MILLIDEGREE

By Dr. WILLIAM E. KELLER

University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico

AT the present, cryogenists have engaged in what we might call the "Battle of the Millidegree". A millidegree to most of us is a trivial thing, but this trivium is in this conflict the symbol which represents a difference in principles; but unless the differences are resolved we may expect an unnecessary and unwanted rift in friendly relations, as well as a great deal of wasted effort. Here are described the principles behind which the opponents stand, and these are reflected in terms of millidegrees as illustrated.

Events leading to the Battle

The emphasis in low-temperature physics has constantly shifted toward a more quantitative description of the unusual behaviour of matter manifested under the conditions of extreme cold. This shift is the natural consequence of the fact that the frequency of discovery of new effects is decreasing; greater effort is being focused on the employment of newer techniques and instrumentation to obtain more detailed information about the older, still unexplained effects. In this progress toward more decimal places in the results obtained at low temperatures, the temperature scale plays a fundamental part. Although the degree of accuracy of the temperature scale required for a particular experiment will vary, it is clear that a temperature standard is needed that is at least as accurate as the most critical demand. We seek a standard temperature scale that approximates to the thermodynamic scale as closely as possible, is smooth, and against which secondary thermometers can easily be calibrated.

Gas thermometry has long been recognized as the most reliable technique for establishing the thermodynamic scale, and since 1924 the vapour pressure of liquid helium-4 has been regarded as the most convenient secondary standard for temperatures below 5·2° K., the critical temperature of helium-4. Workers at the Kamerlingh-Onnes Laboratory at Leyden established in 1924 the first scale for use below 5·2° K.; this was afterwards revised at that laboratory in 1929, 1932 and 1937. In 1948 representatives of cryogenic laboratories in Great Britain, Holland and the United States informally agreed[1] on a scale based upon the thermodynamic formula of Bleaney and Simon[2] below 1·6° K., the vapour pressure measurements of pure helium-4 liquid due to Schmidt and Keesom[3] between 1·6° K. and 4·3° K., and five helium-4 vapour-pressure points determined by Kamerlingh-Onnes and Weber[4] between 4·3° K. and 5·2° K. This vapour pressure–temperature relation, though not published, has been used as a temperature-scale by most low-temperature laboratories from 1948 to the present day. Even before the adoption of the 1948 scale, Kistemaker[5] at Leyden had indicated that between 1·6° K. and 2·2° K. the Schmidt and Keesom data were in error by possibly as much as 0·013° K. Pending independent confirmation, this information was not used in determining the 1948 scale. Subsequent investigations[6–8] have confirmed Kistemaker's suspicions and have extended the range over which the 1948 scale is apparently in error. In addition, the p–T relation has been found[9] to be not smooth, exhibiting undesirable discontinuities in slope. It became evident that this scale was inadequate to satisfy the pressing demands for a reliable temperature scale in the liquid helium region.

When cryogenists met at the International Conference of Low Temperature in Paris, in September 1955, they were presented with two temperature scales, each proposed as the successor of the 1948 scale. Here germinated the dispute one hopes to settle. Both scales are given in terms of helium-4 vapour-pressure; but the two are derived from different kinds of experimental data. The scales are different numerically; but the difference is sufficiently small that a choice between them made solely from a casual glance at the tables becomes impossible. Had either scale been the only one proposed, it would have undoubtedly received unanimous acceptance as a vast improvement over the older scale. Yet since there are two scales, every laboratory or every individual working in low-temperature physics must eventually take sides and must decide which scale is to be used in reporting results. To make this decision we have to resort to a critical examination of the two scales.

Scale T_{55E}

This scale was offered by J. R. Clement, of the United States Naval Research Laboratory. This scale has not been published, but has been circulated among various laboratories. A preliminary report was presented at the Paris Conference; at the National Science Foundation Conference on Low Temperature Physics and Chemistry, held in Baton Rouge, Louisiana, in December 1955, a more detailed account was given, including new information, not appreciated at the time of the Paris Conference, concerning the basis for the scale. This scale has been designated as T_{55E}.

Tables of T_{55E} present the vapour-pressure relation in terms of mm. mercury at 0° C. as derived from the following equations.

$$\ln p = 6{\cdot}22077 - 8{\cdot}3861\,T^{-1} + 0{\cdot}945 \ln T + 0{\cdot}2475\,T \quad (1)$$

valid for $2{\cdot}1735° \text{ K.} < T < 5{\cdot}1911° \text{ K.}$, and

$$\ln p = 5{\cdot}04862 - 7{\cdot}18132\,48435\,T^{-1} + 2{\cdot}5 \ln T - 4{\cdot}74978\,06722 \times 10^{-5}\,T^{9} \quad (2)$$

valid for $0° \text{ K.} < T < 2{\cdot}1735° \text{ K.}$

Equation (1) is not thermodynamic in form; but the first three terms on the right-hand side of equation (2) do have thermodynamic significance (cf. equation 3). Both equations were required to yield a smooth and

reasonable table of p–T values fitting the measured points with the least deviation: smoothness is ensured because the relations are analytical; the table is reasonable since the derivatives conform to those as dictated by the thermodynamical behaviour of helium-4 (cf. Fig. 2 and accompanying discussion). The equations are fitted to two types of helium-4 vapour-pressure measurements, those obtained with gas thermometers (absolute) and others used as interpolation devices (relative).

Between 1·5° K. and 4·0° K. the only existing gas-thermometer measurements independent of low-temperature (below 21° K.) fixed points are obtained from ten isotherms of gaseous helium-3 and helium-4 measured by Keller[9]. In these experiments, temperatures obtained by extrapolating the isotherm data to zero density were used for calibrating a helium-4 vapour-pressure thermometer placed in the gas sample. Amounts of gas contained in the sample pipette were determined at room temperature. Above 4·2° K., vapour-pressure data have been refined by Berman and Swenson[10], who also employed a helium-4 vapour-pressure bulb in contact with a helium-4 gas thermometer. Amounts of gas in the thermometer were generally determined at the normal hydrogen boiling point; but one series of results was referred to a temperature near the helium boiling point. These two sets of gas thermometer measurements form the basis of T_{55E}. Although the temperature ranges of the two experiments do not overlap, Clement has found that the data join smoothly according to equation (1) when 20·375° K. is taken as the boiling point of hydrogen[11]. Clement has re-analysed the Berman and Swenson points, including Swenson's recalculation[12] of the data using the second virial coefficients of helium-4 as computed by Kilpatrick *et al.*[13], and finds that equation (1) fits the data above 4·2° K. with a mean deviation of 0·0020° K. At the same time, the points of Keller are fitted by equations (1) and (2) with a mean deviation of 0·0013° K. (one point having seven times this deviation and showing complete inconsistency with magnetic measurements has been omitted from this analysis and was omitted by Clement in determining the scale).

Since the gas thermometry points are not as closely spaced in temperature as would be desired, Clement has utilized two types of measurements as interpolation devices: (1) observations of the resistance of carbon resistors vs. vapour-pressure by Clement and co-workers[14] and by Corak *et al.*[7]; and (2) data of the magnetic susceptibility of paramagnetic salts as a function of vapour-pressure by Erickson and Roberts[6] and by Ambler and Hudson[15]. T_{55E} agrees with all these measurements within experimental error when the data are normalized to the gas-thermometer points. There is no theoretical basis for the resistance-temperature relation for carbon resistance-thermometers. However, the temperature-scale measurements of Corak *et al.* are calculated with reference to the dependence on temperature of the atomic heats of the noble metals, for which there is a theoretical foundation. Hence these data assume a more significant role in that when the points below 4° K. are normalized to Keller's isotherm measurements, the points above 4° K. can be considered to have validity similar to gas-thermometer data. When treated in this manner, the points above 4° K. agree exceedingly well with the Berman and Swenson points. Whereas most of the vapour-pressure data used in determining T_{55E} was obtained from apparatus using a small amount of liquid in a closed tube, it is noteworthy that measurements of this type by Corak *et al.* are in agreement with results they obtained using the bath pressure with a correction for hydrostatic head.

Scale T_{L55}

The second scale is proposed by H. van Dijk and M. Durieux, of the Kamerlingh-Onnes Laboratory, Leyden. This scale also has not as yet been published, but was presented at the Paris Conference. Copies of the scale, along with a brief description of the method used in obtaining it, have been circulated to a number of interested persons. This scale is designated as T_{L55}.

Scale T_{L55} below 4·167° K. is derived from a vapour-pressure equation which is thermodynamic in form:

$$\ln p_{mm} = i_0 + \frac{5}{2}\ln T - \frac{L_0}{RT} - \frac{1}{RT}\int_0 S_l\,dT + \frac{1}{RT}\int_0^p v\,dp + \ln\left(1 + \frac{B}{v_g}\right) - \frac{2B}{v_g} \quad (3)$$

where i_0 is the chemical constant, R the gas constant, L_0 the latent heat of vaporization at 0° K., S_l the liquid entropy, v_l the liquid volume, v_g the vapour volume, and B the second virial coefficient of the gas. Between 4·167° K. and 5·2° K., van Dijk and Durieux use a slight modification of the original Berman and Swenson vapour-pressure equation.

The thermodynamic form of equation (3) is a desirable feature and endows the scale derived from the equation with an aura of respectability; I must, however, caution that the form by itself does not *ensure* a close approach to the thermodynamic temperature scale; that the accuracy of any scale calculated from the equation still depends upon the reliability of the experimental data used for the calculations. We note that the p–T relation of equation (3) depends explicitly on experimental thermal and state data and, as I shall show below, only indirectly (yet importantly) on vapour-pressure measurements. An examination of the accuracy to which the several terms of equation (3) are known reveals the following: i_0 can be accurately determined from statistical mechanics; with T the independent variable, 5/2 ln T gives no trouble; the term involving v_l makes a small contribution to ln p with v_l sufficiently well known; the terms in L_0, S_l and the gas-correction factors are large, and I consider it necessary to inquire further whether the quantities entering into them have been determined with sufficient accuracy to establish a reliable p–T relation.

L_0 has not been directly determined by experiment. To evaluate L_0, van Dijk and Durieux solve equation (3) for L_0 and, using some provisional p–T relation along with the other necessary experimental quantities, obtain L_0 at a number of temperatures between 1·5° K. and 4·2° K. A constant value of L_0 would be expected if all the data were exact. Since this constancy was not achieved, the assumption was made that the gas correction terms are accurately known, so that the entropy term as derived from specific heat data contributes the only remaining uncertainty. (For a discussion of possible uncertainties in the gas correction term, see below.) Then

another thermodynamic representation for L_0 is used, namely :

$$L_0 = L_T - \frac{5}{2}RT + \int_0^T C_l dT + \int_0^p v_l dp - \frac{RT}{v_g}\left(B - T\frac{dB}{dT}\right) \quad (4)$$

where L_T are the experimentally observed heats of vaporization[16,17] and C_l is the liquid heat capacity. In equations (3) and (4) the terms involving the heat capacity occur in the solutions for L_0 with opposite signs. When L_0's from the two equations are plotted against temperature, deviations from constant L_0 will therefore be of opposite signs in regions where the errors in C_l are dominant. From this plot between 1·5° K. and 2·2° K., van Dijk and Durieux obtain an average L_0 of 59·5 joules/mole ; they accept this value of L_0 and ascribe to it an uncertainty of 0·1 joule/mole. At higher temperatures the two evaluations of L_0 diverge from this value ; van Dijk and Durieux then adjust the specific heat data between 2·5° K. and 4·2° K. so that the two coincide in this range. The adjustment of C_l is well within the experimental error of the heat capacity measurements. In making this analysis the Keesom and Schmidt[18] value of the helium-4 boiling point, judged to be accurate within 0·002° K., was obtained.

In deriving T_{L55}, van Dijk and Durieux have used for C_l "the best Leiden values". These we presume to be gathered from the 1932 data of Keesom and Clusius[19] (1·3°–4·2° K.), the 1932 data of Keesom and Miss Keesom[20] (1·3°–3·0° K.), the 1935 data of Keesom and Miss Keesom[21] (1·22°–2·28° K.), and the recent work of Kramers, Wasscher and Gorter[22] (0·25°–1·85° K.). Apparently the measurements of Hercus and Wilks[23] between 1·10° and 2·05° K. have been passed over. These results are about 10 per cent higher than those of Kramers, Wasscher and Gorter, and to my knowledge no satisfactory explanation has been offered for the discrepancy. Incidentally, use of the Hercus and Wilks data in the above analysis for L_0 would yield a value higher than 59·5 joules/mole by more than the 0·1 joule/mole uncertainty ascribed to this number. Above 2·3° K. the 1932 C_l data are the latest available. The authors[19,20] consider their results in this region to be accurate to within 3 per cent. We conclude that the entropy values derived from these C_l data are at least uncertain by 3 per cent.

To account for the effect of gas imperfection, van Dijk and Durieux use values of B calculated by Kilpatrick, Keller and Hammel[13]. These calculations were made to fit the measured low-temperature helium-4 B values[8] ; the mean deviation of the five observed B values from the calculated ones is about 1 per cent. Since the calculations serve essentially to give a smoothing function for the measurements, they can tell us nothing about the absolute accuracy of the results. Thus we feel that the calculations cannot give B as a function of T with an uncertainty of less than 1 per cent.

Let us now examine the consequences of the above discussion of the possible errors in the quantities entering the tabulation of T_{L55}. In Table 1 is listed an uncertainty, ΔT, in temperatures calculated from equation (3) when we consider the possible uncertainty in the values of L_0, S_l and B separately. We believe that the limits of error cited are all conservative estimates.

Table 1

T° K.	ΔT due to : ± 0·15 per cent in L_0	± 3 per cent in S_l or C_l	± 1 per cent in B
2·15	0·0020	0·0010	0·0002
3·50	0·0025	0·0125	0·0017
4·00	0·0027	0·0180	0·0030

This table is presented not to imply that T_{L55} is in error by as much as 0·018° K. but to illustrate the compliancy available for fitting the data. As an example, let us assume $L_0 = 59{\cdot}5$ joule/mole and B correctly known ; then we insert in equation (3) the Schmidt–Keesom helium boiling point temperature, 4·2160° K., and vary C_l to obtain the chosen L_0. Next let us change the values of L_0 and B by the respective percentages indicated in Table 1 so as to produce a maximum deviation (about 0·006° K.) from 4·2160° K. when we solve equation (3) for T. We may then return to the starting temperature by making an additional change in S_l of only about 1 per cent. With these altered values we can also calculate L_T in agreement with experiment. Using T_{L55} we can apply the same procedure in the region where the error in S_l is the dominant one, above about 2·3° K. For example, at 3·50° K. and 4·00° K. we find the corresponding maximum deviations from T_{L55} to be 0·0042° K. and 0·0057° K., when we effect a 1 per cent change in B and a 0·15 per cent change in L_0. Hence we see that above 2·3° K. we can arrive at T_{L55} by simultaneous corrections to L_0, B and S_l, whereas van Dijk and Durieux correct only S_l. In other words, it is admitted at the outset that the experimental data are not sufficiently accurate to give a reliable temperature scale consistent with thermodynamics. However, it is hoped that the data can be juggled within experimental error to give such a scale. I wish to emphasize that since the three quantities L_0, B and S_l are all to some extent uncertain, the decision to alter only the most uncertain term is indeed arbitrary and offers by no means a unique approach. Conversely, if we are trying to construct a temperature scale from these quantities we have no way of knowing *a priori* how much each of the three quantities should be corrected, and we can end up with any number of scales consistent with equation (3) within the limits described above, unless we make use of suitable additional information such as experimental vapour-pressure data. Finally, below 2·3° K. the error in L_0 becomes dominant rather than that in S_l. However, we have already seen that the value of L_0 chosen by van Dijk and Durieux is in itself strongly dependent upon the choice of specific heat data in this region.

Numerical Comparison of T_{L55} and T_{55E}

A graphical comparison of the two proposed scales is shown in Fig. 1, where T_{L55}–T_{55E} is plotted against T. It is noticeable that below 4·2° K. the two scales differ by at most 0·0036° K. ; but I am struck by the fact that above 4·2° K. the difference increases to about 0·012° K. at 5·2° K., even though in this region both scales are based on the Berman and Swenson[10] data. Van Dijk and Durieux have bodily shifted the original Berman and Swenson equation by about 0·001° K. (in the direction of better agreement with T_{55E}) in order to make it join with the thermodynamic calculation at 4·167° K. However,

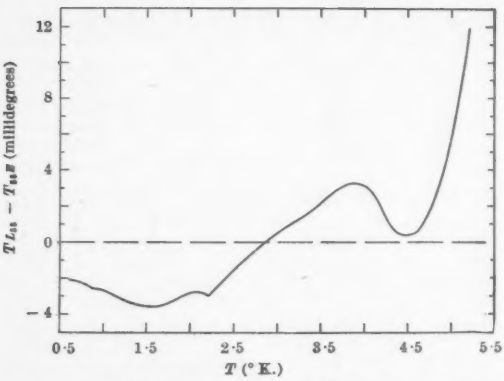

Fig. 1. Deviations of scale T_{55E} from scale T_{L55} in millidegrees plotted against the temperature in degrees Kelvin

serious difficulties are encountered in making this junction, as shown in Fig. 2, where the plots of $-\left[\frac{5}{2}T + \mathrm{d}\ln p/\mathrm{d}\left(\frac{1}{T}\right)\right]$ vs. T for the two scales are compared[24]. Since we know of no anomaly occurring above the λ-point for helium-4, we expect the curve to be smooth above this temperature. The sharp change in slope exhibited by T_{L55} at 4·167° K. is therefore entirely inconsistent with our knowledge of the thermodynamic behaviour of helium-4. From the same curves we may note that with respect to the λ-point anomaly T_{L55} is based on a third-order and T_{55E} a second-order transition. This difference has negligible effect on the temperature scale.

Clement[24] has calculated L_T and C_l using the first and second derivatives of the p–T relation for T_{55E}, together with experimental data of state for the liquid and vapour. The results agree, within experimental uncertainty, with the measured values of these quantities and at the same time differ slightly from the values associated with T_{L55}. Hence, for temperatures below the boiling point, both scales are compatible with our present knowledge of the thermal properties of helium-4.

In making a comparison between any interpolation device, such as carbon and paramagnetic salt thermometers, and a supposed absolute scale, a decision must be made as to which 'tie-down' points are to be used for normalization of the relative measurements. If the absolute scale really were entirely correct, any points would do, provided a sufficient number were taken to determine the unknown constants of the relationship between temperature and resistance (or magnetic susceptibility). However, since we do not have as yet a true thermodynamic scale, it is often best to obtain in some way an average fit. In making such averages we find that the magnetic and resistance data cannot distinguish between the two scales, except as noted earlier in connexion with the resistance data above 4° K. This failure, however, does not detract from the validity of the use of these data for interpolation. I should like to point out that earlier magnetic experiments by Ambler and Hudson[15], which apparently gave a superior fit to T_{L55}, have been repeated[25] and now agree equally well with T_{L55} and T_{55E}.

In the region of the λ-point a comparison of T_{L55} with T_{55E} reveals a subtle yet significant difference. The vapour-pressure of pure liquid helium-4 at the λ-point is measured in relation to the abrupt change in some property of the liquid and is therefore not dependent on any temperature scale. In conjunction with tables of T_{L55} van Dijk and Durieux state this pressure to be 37·67 mm. mercury at 0° C. as determined from the "most accurate Leiden measurements". On the other hand, equations (1) and (2) defining T_{55E} were made to join with continuous $\mathrm{d}p/\mathrm{d}T$ at a λ-point pressure of 37·86 mm. mercury. This figure was arrived at from an average of four recent determinations, including the Leyden value, and those of Long and Meyer[26] (37·96 ± 0·02 mm. mercury), Erickson and Roberts[6] (37·91 ± 0·05 mm. mercury), and unpublished measurements[24] made at the U.S. Naval Research Laboratory. Newer measurements by Dash and Taylor[27] giving 37·86 ± 0·05 mm. mercury substantiate the value selected for T_{55E}. We have no satisfactory explanation for the failure of van Dijk and Durieux to include some of the other data for the selection of a λ-point pressure. Since some of the properties of liquid helium change so markedly at the λ-point, it is often of importance to the experimenter to know on which side of this point his experiment is being conducted; we can imagine his dilemma when he measures a vapour pressure of 37·75 mm. mercury and sees from T_{L55} that the temperature is above the λ-point, whereas according to T_{55E} it is below the λ-point.

Conclusions and Recommendations

Now that the discussion concerning the background of the causes of dissension leading to the 'Battle of the Millidegree' is completed, I propose to assess the relative merits of each side. We cannot permit ourselves to lean back indifferently and consider that the whole affair is a tempest in a teapot, that, after all, what matter a few millidegrees, more or less! Even though both proposed scales represent a considerable improvement over the 1948 scale, we feel that the unfavourable consequences of having two scales must be avoided so far as possible. In theory, each scale is capable of closely representing the true thermodynamic temperature; but we must admit the possibility that neither does in practice; T_{L55} approaches the problem by constructing a non-unique p–T relation from the best available experimental thermal data, while T_{55E} does this from the best available experimental p–T data. We must decide to use the one scale which will best serve low-temperature research until more accurate experimental evidence of both kinds is obtained.

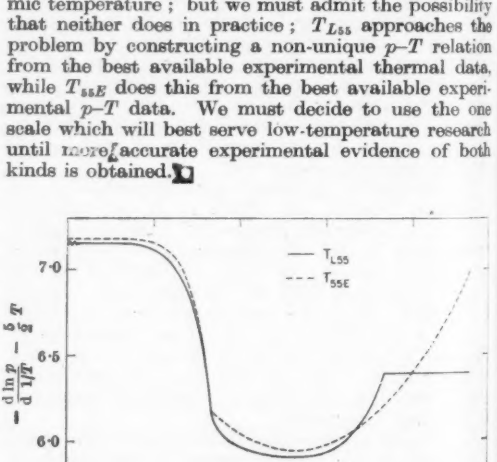

Fig. 2. A plot of $-\mathrm{d}\ln p/\mathrm{d}(1/T) - 5/2\ T$ vs. temperature for T_{L55} and T_{55E}

I favour T_{58E} primarily because I believe that it more closely represents actual vapour-pressure–temperature measurements as determined in the laboratory. I feel this is true not only concerning the λ-point pressure and the region between 4·2° K. and 5·2° K., as I have discussed in some detail, but also of the region below 4·2° K. as well. I consider it extremely reassuring that a single equation, such as equation (1), can fit the results of several independent investigators over so wide a temperature range with such a remarkably small mean deviation. In short, if the temperature scale is to be based on the helium p–T relation, I prefer a scale derived from data and procedures which directly match those used in obtaining temperatures in everyday experiments.

It is, of course, very desirable to tie everything up in one package, to obtain with equation (3) a complete thermodynamic description of helium-4 along the saturation curve and thereby arrive at a temperature scale. Above 4·2° K. it is at present out of the question to employ the method of van Dijk since the necessary data do not exist. Below 4·2° K. we have seen that there are uncertainties inherent in the thermal and state data such that an accurate temperature scale can be obtained only through reliance upon experimental p–T data as a guide.

From the above discussion it can be seen that a single scale could have been derived by combining T_{Lss} and T_{58E} and retaining the more favourable features of each. Above 4·2° K. it is undoubtedly best to represent the scale with equation (1). Below 4·2° K., equation (3) could be made to fit the experimental vapour-pressure measurements through utilization of the considerable compliance in the thermal and state data (Table 1). This would essentially amount to using the numbers of T_{58E} and the form of T_{Lss} without compromising the stated accuracy of any of the pertinent experimental data. Had such a scale been presented in place of the other two, it would have undoubtedly been favourably received; the merger can still be effected, but not without considerable effort. Lacking this reconciliation, we are forced to decide between the form and the numbers. I believe it is safe to assert that cryogenic experimenters attach more importance to the latter. The numbers exist in the tables of T_{58E}, and I recommend that these be used.

The arrival at the above conclusion is not tantamount to a proclamation of victory for either side, for the real question of which scale is overall closer to the thermodynamic scale cannot be answered on the basis of the existing evidence. It does, however, present the more reasonable interim scale for practical use and allows all concerned to withdraw from battle and go about the business of obtaining new information necessary for determining a thermodynamic scale.

I wish to state that, though the above decision was arrived at independently, my confidence in it has been bolstered by the concurrence of the staff members of the Cryogenics Group, Los Alamos Scientific Laboratory, namely, E. F. Hammel, E. R. Grilly, J. G. Dash, R. D. Taylor, R. H. Sherman, E. C. Kerr, A. F. Schuch, T. R. Roberts and S. G. Sydoriak. All the material presented has been thoroughly discussed with these individuals, and, indeed, ideas for some of the arguments given were conceived by them. I am grateful for their help and criticism. In addition, it is a pleasure to acknowledge as a source of information and stimulation helpful discussions with J. R. Clement, R. P. Hudson, E. Ambler, H. van Dijk and M. Durieux. This work was performed under the auspices of the U.S. Atomic Energy Commission.

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SCIENTIFIC AND ENGINEERING MAN-POWER IN GREAT BRITAIN

THE recently issued report on scientific and engineering man-power in Great Britain* embodies the results of two related inquiries. The results of the first, initiated by the Ministry of Labour and National Service, and carried out with the help of the Social Survey, which was concerned with the present number and distribution of scientists and engineers, and with the demands of industry and the other main users of scientific man-power in three years time, are set out in the second part of the report. The second study, the conclusions of which are given in the third part, was made by the Committee on Scientific Man-power of the Advisory Council on Scientific Policy and was concerned with the probable trend in the long-term demands for scientists and engineers. Its purpose is to set a goal for the universities and the technical colleges of Britain, so that present and future demands for trained scientific man-power may be met.

* Scientific and Engineering Manpower in Great Britain: a Report on the Number and Distribution of Scientists and Engineers now employed in Great Britain, and a Study of the Likely Trend in the Future Demand for Scientific and Engineering Manpower. (London: H.M.S.O., 1956.) 1*s.* 6*d.* net.

In the present inquiry, the terms 'scientist' and 'engineer' are used to cover the basic sciences on one hand and the applied sciences in the engineering field on the other. The term 'scientist' in this report covers biology, chemistry (other than pharmacy), geology, mathematics, physics, and general science, while the term 'engineer' covers persons with a degree or other professional qualification in chemical engineering, civil and structural engineering, electrical engineering, mining engineering, mechanical, aeronautical and other branches of engineering, and metallurgy. The report thus excludes those who have studied science at the universities but qualified in agricultural science, dentistry, medicine and veterinary science, and it does not include people with specialized qualifications in certain fields of technology such as textiles and rubber. The social sciences are likewise excluded. Its attention is concentrated on the demand for 'qualified' scientists and engineers, and this is taken to mean those with a university degree in these fields or who are associates of certain bodies such as the Manchester College of Technology, or corporate or graduate members of the professional institutions listed.

The Ministry of Labour's inquiry was linked with an inquiry on behalf of the Department of Scientific and Industrial Research into the proportion of industry's resources spent on research. Information was obtained from all manufacturing establishments employing 500 workers or more, and from a sample of those with between 100 and 499 workers. Establishments with less than a hundred workers were not approached. Slightly different sampling arrangements were used in the building and contracting industry; information was obtained from the boards of nationalized industries, central government departments and local authorities, but agriculture, the non-nationalized parts of the mining and transport industries, shipping, the distributive trades and miscellaneous service industries were not covered.

For early 1956 the inquiry gives the total of qualified scientists as 51,230 and of qualified engineers as 119,700, of whom 32,150 possess higher national certificate or diploma or its equivalent; and of these last, 22,790 are employed in manufacturing industry, 5,330 in nationalized industries (including the Atomic Energy Authority), 1,710 by the central government and 320 by local authorities. For qualified engineers as a whole, the corresponding figures are 37,000, 14,660, 8,050 and 6,330, with a further 2,430 in education; and for qualified scientists, 17,050, 2,420, 5,890, 350 and 25,610. Rough estimates put the number of qualified scientists in other employment at 5,000 and of qualified engineers at 10,000, making a grand total of 134,700. Besides this, there are about 4,700 qualified scientists and 2,300 engineers engaged in postgraduate research at the universities or at present on National Service.

Of the 134,700 qualified scientists and engineers, or about 0·6 per cent of the working population of 24 million, there are thus about 43 per cent in manufacturing industry, 12·5 per cent in the nationalized industries, 21 per cent in teaching, 10 per cent in central government establishments, 5 per cent in local government, and 8 per cent in miscellaneous occupations. Nearly half the qualified scientists are engaged in teaching, and three-quarters of the qualified engineers are in industry.

These scientists and engineers are concentrated in a relatively few industrial groups. Of 48,829 engineers and scientists in manufacturing industry, the numbers were distributed as follows: chemicals (8,300), other plant and machinery (6,700), electrical engineering (12,200) and aircraft manufacture (4,300), accounting for only three-tenths of the labour force, and include nearly two-thirds of the scientists and engineers. While the average proportion of scientists and engineers to the total employed is 0·8 per cent for all industries, it varies widely from one industry to another; from 10·9 per cent for the Atomic Energy Authority (for which the total in 1956 was 2,467, of whom 1,706 were engaged in research and development) to as little as 0·4 per cent in shipbuilding and motor manufacture and less than 0·25 per cent in cotton, wool and wood, cork, paper and printing. Only in mineral-oil refining (5·2), the electricity authorities (2·9), chemical and allied trades (2·7), electrical engineering (2·0), aircraft manufacture (1·9), constructional engineering (1·5), Gas Council and area boards (1·2), non-ferrous metal manufactures (1·1), rayon, nylon, etc. (1·1), and other plant and machinery is it 1·0 per cent or more.

Of the 13,900 scientists and engineers in government service, just over a half are in the defence departments (including the Ministry of Supply), just over a quarter in the Civil departments, and one-sixth in the Department of Scientific and Industrial Research, the Agricultural Research Council, the Medical Research Council or the Nature Conservancy. Of the 6,700 employed by local authorities (other than for teaching) 80 per cent are civil engineers. Of the 25,600 scientists and 2,400 engineers engaged in teaching, 13 per cent are in the universities, and of those teaching in schools more than a quarter are in Scottish schools.

Of those employed in manufacturing industry, about 45 per cent were engaged in research and development, 47 per cent in production, maintenance and installation and the remainder on 'other work', many of whom may not be engaged directly on any form of scientific or engineering work. So far as the figures go, they suggest that well above average proportions are engaged in research and development in the aircraft, electrical engineering, precision instruments, etc., and rayon, nylon, etc., industries, and well below average in shipbuilding and repairing, railway equipment, iron and steel, non-ferrous metal, and other plant and machinery.

Dealing next with the demand for scientists and engineers in the next three years, the report gives the 1959 requirements of industry in Britain at 94,640—an increase of 33 per cent—the increase in manufacturing industry, building and contracting, research associations and nationalized industries (including the Atomic Energy Authority) being given as 37·0, 32·0, 21·0 and 22·0 per cent, respectively. For government departments, local authorities and teaching, an increase of 14·0 per cent for 1959 to 55,400 is reported. For the central government, the increase from 13,850 to 15,850 is mainly in the research departments (23·0 per cent), compared with 12·0 per cent in defence departments and 14·0 per cent in civil departments. For local authorities an increase of 27·0 per cent is reported and for teaching 11·0 per cent, of which 34·0 per cent is estimated for the universities, though this figure is conjectural, being estimated before the University Grants Committee had received the universities estimates for 1957–62.

Among categories of scientists, the greatest numerical increase in the next three years is estimated for chemists (4,500 or 22 per cent), physicists coming

next with 2,400 (23 per cent), and mathematicians with 1,500 (13 per cent). For biologists the figures are 600 (12·5 per cent); for geologists, 200 (22·0 per cent); and for other scientists, 300 (11·0 per cent). Among engineers the greatest demand in numbers is expected for mining and other engineers (8,800 or 33·0 per cent), for electrical engineers (5,100 or 23·0 per cent) and for civil engineers (3,400 or 27·0 per cent). For metallurgists the figures are 1,200 (38·0 per cent); mechanical engineers, 1,000 (26·0 per cent); chemical engineers, 700 (47·0 per cent); and for engineers in teaching, 600 (25·0 per cent).

The Committee on Scientific Man-power bases its assessment of the long-term demand for scientists and engineers on the assumption of an overall expansion of industrial output of 4 per cent a year, and that this is only possible if there is an adequate supply of scientists and technologists. This involves assumptions of increases of 7 per cent and 5·25 per cent for the chemical and engineering industries, whereas only 2·5 per cent is assumed for the textile industry. Replies received to the Ministry of Labour questionnaire indicate that, without qualification, manufacturing industry expects to employ 37 per cent more scientists and engineers in 1959 than in 1956; but this figure reflects a considerable margin for current shortages of qualified men. The Committee attempted to isolate this element by assuming that the demand for trained man-power in each industry would, at the least, rise in relation to the number now employed by the same proportion as output is expected to do over the next three years. The difference between this estimate and the figure supplied by industry is taken to represent the presumed current shortage; and an allowance for this factor has been added to the number currently employed, before making the extrapolations based on changes in output over the next ten years. The result is an estimate of the demand for scientific man-power in terms of the number of scientists and engineers necessary to permit an increase in industrial output of 4 per cent per annum.

The estimates for government departments are based on existing policies and allow only for a very modest increase over the next ten years. Sufficient teachers are postulated to deal with the increased number in secondary schools, but not for any further concentration on scientific subjects or for any improvement in existing staffing ratios, for which about four thousand additional science graduates would be a reasonable assumption. Requirements of the universities are assumed to increase by about 100 per cent over the period.

The broad conclusion is reached that an increase of rather more than 60 per cent is required—from about 135,000 to about 220,000 in 1966—the increase for engineers being about 70 per cent and for scientists about 50 per cent. The annual gross flow of those qualified in pure and applied science from the universities and technical colleges is to-day a little more than 10,000—roughly about half scientists and half engineers—and this could well rise to 12,000 by 1958–59. During the next five years, some 60,000 people qualified in science and engineering might come from the universities and technical colleges of Great Britain; but this would have to rise to 16,000 a year if the figure of 220,000 is to be reached by 1966. Allowing 25 per cent for overseas students, emigration, etc., and some continued measure of shortage, the Committee estimates that an annual output of 16,900 in 1966 and 19,900 in 1970 is required.

The Committee recognizes that its estimates involve some margin of error, but it points out that it may well have taken too conservative a view of the demand that is likely to develop in some sectors of the economy. It suggests, however, that the estimates point to a reasonable objective for the universities and technical colleges. In conclusion, the Committee emphasizes that, at the national level, an annual figure of 'graduations' in pure and applied science of about 20,000, as compared with the present 10,000, is the minimum at which we should aim over the next ten to fifteen years, if the economy of Britain is to grow at an acceptable rate.

METALS IN LIVING SYSTEMS

A SYMPOSIUM on "Metals in Living Systems" occupied the morning session on September 3 of Section B (Chemistry) during the recent Sheffield meeting of the British Association. It was opened by Sir Rudolph Peters with a few remarks about the role of metals in a variety of enzyme reactions and the importance of metals for the metabolism of all forms of life. He gave some examples of how the biochemist could elucidate the actual function of a metal in an enzymic reaction. In particular, he mentioned the importance of the complex formation between metals and sulphydryl groups as shown, for example, in the interaction of ferrous iron, cysteine and aconitase, studied in his laboratory by Morrison. Sir Rudolph emphasized the complexity of some of the problems by referring to the recent work on the composition of xanthine oxidase.

Prof. A. Neuberger (London) discussed the structure and biogenesis of porphyrins and related compounds. Simple pyrroles have so far not been found in Nature, with the notable exception of the aminomethyl pyrrole, porphobilinogen, which is an intermediate in the biosynthesis of porphyrins and is excreted in the urine of patients suffering from acute porphyria. Much more widespread—and of the greatest importance in connexion with the present discussion—are the macrocyclic tetrapyrrolic structures found in hæmoglobin, chlorophyll and vitamin B_{12}. Prof. Neuberger first discussed the porphyrins forming part of the hæmoglobin, catalase and peroxidase molecules and the type of resonance found in the porphyrin structure. He then briefly considered the types of bond formed between the central iron atom in hæm and the heterocyclic pyrrolic systems. The interaction between the hæm and protein moiety of the hæm proteins was considered and the various types of isomers arising from changes in the order of the 'outer' substituents of the porphyrin ring were mentioned. Turning to the chlorophylls, Prof. Neuberger pointed out that these contain as the central atom not iron, but magnesium, and also differ from the hæm compounds in the degree of saturation of the heterocyclic system. The work of Linstead and his co-workers on the location of the 'extra' hydrogen

atom in the chlorophyll molecule was also mentioned. The third type of macrocyclic pyrrolic structure considered was that present in vitamin B_{12}. In this molecule, as shown by Dr. D. C. Hodgkin and Sir Alexander Todd, the macrocyclic system is reduced to a much greater extent than in porphyrins or chlorophyll, and not all the pyrrolic rings are linked, as in the porphyrins or chlorophyll, by methene bridges. Two of the rings are joined by a direct linkage, giving a dipyrryl structure. In addition, the central atom is cobalt.

Prof. Neuberger then traced the development of recent work on the biosynthesis of porphyrins, starting from the discovery in 1946 by Shemin and Rittenberg that the nitrogen atom of glycine is specifically used in the biosynthesis of porphyrin. He described work done in the department of Shemin and in his own laboratory, work which was mainly based on isotope techniques. The isolation of porphobilinogen by Westall and the elucidation of its structure by Cookson and Rimington in 1953 completed the overall picture. Glycine is condensed with an asymmetrically substituted derivative of succinic acid to give α-amino β-oxoadipate, which loses carbon dioxide to yield δ-aminolævulic acid. Condensations of two molecules of the latter then give porphobilinogen. While the last reaction has been shown to be catalysed by a specific enzyme which has been obtained in a purified form, the initial condensation reaction has not yet been clarified at the enzymic level. Prof. Neuberger mentioned experiments done in his own laboratory which indicated that α-amino β-oxoadipic acid is extremely unstable, and it seems uncertain whether it will ever be made by chemical methods. The possibility exists that this α-amino β-keto acid never occurs as such in the biogenesis of the porphyrin ring. The further changes involved in the conversion of porphobilinogen to the naturally occurring porphyrins were then considered. Experiments of Granick and others indicating that porphyrins are precursors of chlorophyll were then described. Prof. Neuberger concluded by saying that the initial steps in the biosynthesis of the macrocyclic system of vitamin B_{12} are probably identical with those established for porphyrins.

Dr. C. P. Whittingham (Cambridge) spoke on "The Role of Metals in the Green Plant" and started his talk by briefly referring to some nutritional problems met with in ordinary farming and horticulture. For example, potassium is required in more than trace amounts; but other metals which have recently been shown to be important and which are needed in relatively small amounts are manganese, zinc, copper and molybdenum. The plant physiologist who wishes to find out what part a particular metal plays in the metabolism of a plant may observe the physiological effects which result from either using a deficient medium or the addition of a metal poison, that is, a substance combining with a particular metal or a group of metals. This approach was illustrated by some experiments showing the effects of the addition of such poisons to processes such as photosynthesis, nitrate reduction and respiration in *Chlorella*. Another example was the well-known experiment by Warburg in which the inhibitory effect of carbon monoxide on the respiration of yeast is partially removed by illumination. Since it is known that light of the particular wave-length used can cause dissociation of some iron carbonyl compounds, the experiment provides evidence that at least one step in the respiration is probably catalysed by an iron-containing enzyme.

The characteristics of synthetic or assimilatory processes were then discussed in general terms and compared with those of the catabolic reactions. The former are mainly of a reductive nature, such as the conversion of carbon dioxide to carbohydrate in ordinary photosynthesis, or nitrogen fixation or the assimilation of sulphate or sulphite. The catabolic processes on the other hand, in their overall effect, are oxidative. Dr. Whittingham then discussed the various types of oxidation and considered the role of the cytochromes with particular reference to the valency changes which occur in the iron atom. The term oxidation may mean addition of oxygen to an organic compound, removal of hydrogen or just removal of electrons. In the oxidation of succinic acid there is first a removal of hydrogen atoms which is mediated through a flavoprotein complex; but ultimately there is transfer of electrons, which is catalysed by the iron–protoporphyrin complex of the cytochromes. The flavoprotein itself is complexed with a metal and transfers equivalents of hydrogen or electrons—one at a time—to the iron of cytochrome. The importance of the metal in this reaction has been demonstrated by showing that the activity of the flavoprotein is largely lost on dialysing it against cyanide. The exact manner with which the metal in the flavoprotein complex functions is still a matter for discussion.

Dr. Whittingham then discussed the oxidations, such as that catalysed by polyphenol oxidase. Reactions of this type are catalysed by copper-containing enzymes which are widely distributed in higher plants, but their biological importance is still largely undefined. This type of oxidation may be only of minor importance, but the view is held by some workers that it may constitute an important method of electron transport and be an alternative pathway to that catalysed by the cytochrome–flavoprotein system.

Some aspects of photosynthesis were then discussed in detail. Dr. Whittingham mentioned the effect of iron deficiencies on the chlorophyll content of plants and he also described some observations showing that a deficiency of magnesium affects photosynthesis not only by reducing the chlorophyll content. It is likely that this is due to the fact that magnesium is an important constituent of several enzymic systems involved in the assimilation of carbon dioxide.

In the past few years evidence has accumulated showing that cytochromes, somewhat different in structure from those of the respiratory type, are also concerned with photosynthesis. Dr. Whittingham suggested that such a cytochrome system may supply a small, but nevertheless essential, part of the energy required to convert carbon dioxide into carbohydrate. He then discussed some recent work which showed that manganese played some part, not in the reduction of water to a hydroxyl-like radical, but in the oxygen-liberating part of photosynthesis. Another metal, molybdenum, is implicated in the nitrate reductase activity of *Neurospora*. Dr. Whittingham also considered a few other enzymic reactions which involve metals, such as the decarboxylation of keto-acids. He concluded with a few remarks about the role of potassium. This metal is required for the activity of the enzymes fructokinase and pyruvic acid kinase. But it is unlikely that the major cause of its nutritional importance is due to

the co-factor requirements of these enzymes alone. It appears that a purely chemical explanation of the biological activity of potassium in plants, or for that matter in animals, has still to be found.

Sir Rudolph Peters and the audience warmly welcomed Sir John Russell, who in a short talk described how the recent advances in our knowledge of the deficiencies in trace metals were made partly by intelligent interpretation of mistakes in farming, partly by accident, but to a large extent by the application of spectrographic analysis. He gave some instances such as the important economic effects resulting from the realization that certain soils in Australia and New Zealand were deficient in molybdenum, zinc, cobalt or copper, or in combinations of these. He also described briefly the use of iron chelates in Florida.

Dr. D. P. Cuthbertson, director of the Rowett Research Institute, Bucksburn, Aberdeenshire, had most generously agreed to deputize for Mr. Hedley Marston, the head of the Nutrition Division of the (Australian) Commonwealth Scientific and Industrial Research Organization, who was prevented by illness from attending the meeting. Dr. Cuthbertson surveyed in a masterly manner the importance of metals in the nutrition of plants and, in a more cursory manner, of animals, and emphasized the economic importance of the recent work on the importance of the metal content of soil and pasture for the nutrition of sheep and cattle. In the first place, he directed attention to the very specific requirements for metals of both plants and animals. Thus sodium, which is most important in the electrolyte metabolism of animals, does not appear essential for any plant species studied. Certain plants have a very specific capacity for storing certain metals and sometimes in an unexpected manner; thus, legumes are particularly rich in calcium, deciduous fruits in potassium, and some tropical crops have high contents of manganese. Hickory accumulates aluminium and zinc, and the Brazil nut stores barium. Metallic mercury has been observed in the seed capsules of *Holosteum umbellatum*. Iron, copper and vanadium are found in the respiratory pigments of hæmoglobin, hæmocyanin (Cephalopoda and Crustaceae) and hæmovanadin (Ascidae), respectively. Dr. Cuthbertson then mentioned some of the enzymes which contain metals as essential parts of their structures. Thus iron is present not only in hæmoglobin, but also in catalase, the various cytochromes and peroxidase. Zinc is present in carbonic anhydrase. Copper–protein complexes have been isolated from both animal and plant sources, some of which function as enzymes, such as polyphenol oxidase and ascorbic acid oxidase. In this connexion it is of interest to note that workers in the Rowett Research Institute have demonstrated the presence in herbage of a copper–peptide complex which has a greater biological effect than cupric ions in curing copper-deficiency in rats. Recently it has also been shown that molybdenum forms part of the prosthetic group of the enzymes xanthine oxidase and that of nitrate reductase.

Dr. Cuthbertson next discussed the deficiency diseases which may arise in plants or animals through lack of various metals. Lack of magnesium in plants, for example, produces characteristic changes in foliage, and deficiency of this metal is especially serious for fruit trees. Lack of potassium has also been shown to be particularly important for fruit trees. In Australia and New Zealand traces of molybdenum have improved clover production and both there and in the United States the rectification of zinc deficiency has greatly increased the citrus crop. Deficiencies of copper and cobalt have been particularly important for ruminants, and the rectification of such deficiencies in certain areas of Australia and New Zealand particularly has increased agricultural production in certain areas by amounts equivalent in value to many millions of pounds per year. There are also areas in the United Kingdom where grazing ruminants suffer from deficiency of cobalt or copper, and there are certain areas where the growth of horticultural crops—cauliflower in particular—is affected by molybdenum deficiency in the soil. There is now a considerable body of evidence showing the importance of trace-metal interaction—effect of the character of soil and of manurial treatment on the availability of metals to plants. Examples of such antagonism are provided by the interaction of iron and manganese and the observation that a high intake of molybdenum may inhibit assimilation of copper. In conclusion, Dr. Cuthbertson emphasized the interesting relationships which are being uncovered between the identification of metals as constituents of enzymes on the level of biochemistry, the nutritional importance of metals in the nutrition of plants and animals and the application of this knowledge to practical farming all over the world.

EDMOND HALLEY: THE FIRST GEOPHYSICIST

By Sir EDWARD BULLARD, F.R.S.

THE three hundredth anniversary of the birth of Edmond Halley falls this week. When he was born on October 29, 1656, the kinematics of the solar system was understood; but the rest of physical science was little more than disconnected fragments. A few principles or laws, such as the isochronism of the pendulum and Snell's law of refraction, were known, but there was little sign of the immense power and utility of the combination of experiment and systematic theory.

By the time of Halley's death in 1742, all this was changed and a body of knowledge and speculation existed that is recognizably the basis of modern science. It is scarcely an exaggeration to say that a single generation invented the technique, and discovered the content of physical science. What is more surprising, they were, in large measure, conscious of what they were doing. They believed that any fact was worth noting and any natural or industrial process worth investigating. As a young man, at

Oxford and in London, Halley knew all the leading figures interested in this new way of approaching knowledge, and soon became himself one of the best known of them. He was interested in and wrote about everything—mathematics, astronomy, ship's tackle, meteorology, magnetism, diving, archæology, the Chinese language, and how to stop ants climbing trees.

In retrospect the science of the period is overshadowed by Newton's demonstration that the motions of the solar system are a consequence of the principles of dynamics combined with the law of gravitation, and others are apt to be judged by their relation to this achievement. By this test, Halley ranks high as the friend and helper of Newton, who provided the stimulus that led to the publication of the "Principia" and as the developer of Newton's ideas on the orbits of comets. Celestial mechanics was the fashionable subject of the succeeding century and the interest in it has somewhat obscured Halley's other work.

One of Halley's earliest interests was in terrestrial magnetism. At the age of sixteen, while still at school, he made a determination of the magnetic declination at London, finding it to be 2½° to the westward. Twenty years later he collected all the available observations and wrote two papers in the *Philosophical Transactions of the Royal Society* which are remarkable for their insight into the real difficulties of forming a satisfactory theory of the Earth's magnetic field. He correctly followed Gilbert in supposing that the Earth's field is of internal origin, but this led to a difficulty. The change in the declination at London between the earliest measurements in 1580 and those of Halley was 14°, and similar changes were taking place all over the world. He saw that such changes could not be accounted for by movements of magnetized material within the earth without "very wonderful Effects in changing the Axis of diurnal Rotation, and . . . strange alteration in the Sea's Surface, by Inundation and Recesses thereof such as History never yet mentioned". At the same time, the great areas over which the declination had the same sign suggested that the cause was at a great distance from the surface of the Earth. These considerations led Halley to suppose that the causes of the slow variation of the declination lie deep within the Earth, and to suggest that the Earth might possess a magnetized core within a magnetized shell and that the core rotates slowly relative to the shell. He saw that such a hypothesis could account only approximately for the observations and suggested that there might be a series of concentric shells within the Earth each carrying its own set of poles.

This argument and its conclusions come very close to the theories of terrestrial magnetism that are fashionable to-day, except that we can escape the necessity for multiple shells by supposing the core to be liquid and thus to be capable of more complicated motions than the rotation of Halley's solid core.

The interest of the papers is, however, not so much that Halley was largely correct in his arguments and conclusions, as in his approach to the problem. He accepts from the start that this is a complicated subject, that a great many observations are needed and that there is no quick and simple answer. He does not try, as did Bond before him and Whiston after him, to make the observations fit some simple empirical law. He requires the motions and stability of his core to be governed by Newtonian dynamics, but expects that there will be a long period of groping for the relevant factors and that he can only "propose an Hypothesis which after-Ages may examine, amend or refute".

This realization of the complexity of the problems of geophysics is characteristic of Halley, and has only been fully regained in our own day as the tidal wave of observational data has swept away so many tidy generalizations.

Halley had a real delight in collecting observations, discussing them, and devising visual presentations of them. The successive editions of his magnetic charts, with their "Halleyan lines" of equal declination, were used for many years after his death and must have been of great practical value. His wind charts show the trade winds and monsoons with great clarity and considerable detail. In discussing the results he says that, on an Earth covered with water, the north-east and south-east trade winds would doubtless circulate continually all round the Earth, but that on the actual Earth the presence of the land disturbs the regularity of the pattern and produces local phenomena such as the westerly winds of the Guinea coast and the south-west monsoon in India. This approach, with its distinction of a general circulation and local disturbances, is sound enough; but unfortunately the explanation proposed for the general circulation is incorrect. It is surprising that Halley, having studied the winds so carefully, did not anticipate Hadley in realizing the importance of Coriolis forces in atmospheric motions.

Halley's approach to lunar theory is along the same lines. It was known that after a period of 18 years and 11 days the positions and velocities of the Earth and the Moon return very closely to those that they had at the beginning of the period. Halley suggested that after this period, the errors of the lunar tables would repeat themselves, and that after observing for one such period empirical corrections to the tables could be derived and used in the future. He first devised this scheme as a young man, but only seriously started the observations in 1721 when he was sixty-five years of age and he completed the eighteen years of observations two years before his death. The tables were published posthumously in England and in France.

Several other examples could be given of investigations involving the discussion of a large body of data and its reduction to some kind of order; such, for example, as the discussion of the births and deaths at Breslau and the calculation of an annuity table from them. His work on comets involved the calculation of orbits for all those for which sufficient observations existed. In addition to the well-known discovery that some comets are periodic, he noticed that their orbital planes were distributed at random, in sharp distinction to those of the planets. To collect the observations and reduce them must have been a very great task; it is characteristic of Halley that he not only carried the work to completion, but also extracted two major discoveries from it.

Halley's great achievements in theoretical geophysics and in the discussion of observations are the more remarkable when it is remembered that he was also a naval captain, who took a 64-ft. ship southwards to the antarctic ice and also made a detailed survey of the English Channel, and that much of his time was spent in experiments on diving, in the improvement of instruments and in the translation of ancient mathematical texts from Greek, Arabic and Hebrew.

OBITUARY

Prof. Frederick Soddy, F.R.S.

FREDERICK SODDY was born at Eastbourne, the seventh child of his parents, on September 2, 1877, and died on September 22 just after his seventy-ninth birthday, and by his passing we lose a personality at once outstanding and complex. He was educated at Eastbourne College, and although destined to be a student at Oxford he was able to spend a year or more of early student activities at Aberystwyth. After graduation from Merton College, Oxford, in 1898, he considered work in Toronto; but that idea did not come to fruition. He went to Montreal and the very fruitful period of collaboration with Rutherford was commenced, which resulted in the establishment of the concept of the disintegration of the radioactive elements. It is impressive how many experiments connected with thorium and thorium emanation have been shown to be contributory to the formulation of the disintegration concept. In conjunction with Rutherford, he made this most valuable contribution to scientific conception when he was in his middle twenties. It has always been recognized that the conception was a joint effort, and, in so far as his half of the credit is concerned, it indicates a consistent feature in his manner and method of thought. In this he himself in no way minimized the place of imagination and intuition. From Montreal he went to work with Ramsay at University College, London, and from that there came the determination of association of helium and radium emanation.

An interlude of a lecture tour in Australia followed, where his talks illustrated with a quantity of radium drew audiences which were ready to yield very adequate remuneration to the lecturer. By this time the recognition by the University of Glasgow of the need of broadening the basis of chemical teaching enabled him to obtain the position of lecturer in physical chemistry and radioactivity and brought him, in the wider circle of the Chemistry Department, the pleasing and attractive friendship with Cecil Desch, who then occupied a parallel lectureship in metallurgical chemistry.

The years in Glasgow from 1904 to his translation to Aberdeen in 1914 are a very productive period for contributions to advancing science. These years were dominated by three types of activities. First, the very thorough and systematic work in which he purified substantial quantities of uranyl nitrate and then proceeded to measure the rate of growth of radium measured by the increasing quantities of radium emanation. As a series of experimental determinations, they were marked by careful systematic methods.

The second type of work to which he devoted much effort was the development of his technique as a lecturer with an appeal to a general, non-technical audience. He seemed to have the example of Sir William Ramsay in mind, and his "Free" lectures in the Botany Class Room of the University had a wide appeal and helped in a valuable way to disseminate the conceptions involved in the new ideas of radioactivity.

The third major activity was all the work and thought that was involved in the development of the conception of isotopes. Here again his intuitions played a very considerable part, and he was much concerned with the idea that had been evolved in his mind of atoms with different atomic properties, possibly different periods of life and/or different atomic weights, which would nevertheless have the same chemical properties. It was the testing of this concept and its verification that logically led to the $\alpha\beta$ displacement law. From this also came the introduction into our language of the word 'isotope'. It was suggested by Dr. Margaret Todd, arising from a discussion that Soddy had in the house of his father-in-law, Sir George Beilby, in Glasgow.

After the work on isotopes there followed contributions on the atomic weight of lead from minerals containing radioactive elements, in conjunction with Hyman, and work on the actinium series, in collaboration with Cranston.

A Nobel Prize was awarded to Soddy in 1921 after his appointment to the Dr. Lee's chair of chemistry in Oxford, which he held during 1919–36. However, by this time he was making few, if any, contributions to scientific knowledge, and his time was devoted to riding various hobby horses which it is difficult to imagine will ever find a permanent place in the culture of our times. Economic theory, the closest packing of spheres, mechanical means of solving differential equations, all occupied his interest; in general, these activities produced results satisfactory to him but unconvincing to the expert.

It was my privilege to be close to him in numerous types of relationship: first of all as a laboratory boy, secondly as a student for graduation, and then as a research student doing postgraduate work. That was followed by a position of University demonstrator to his lectureship. While these stages were progressing, a personal friendship developed which existed until his death. In all these aspects complex emotions were involved—much generosity, some supersensitiveness, some hard hitting, much breadth of outlook. To his laboratory boy, he was kindness itself and his capacity for encouragement and leadership was unbounded. Responsibility was given freely, and when it was taken successfully it was much appreciated by him. To students working for graduation, the impression was of remoteness, and, so far as my knowledge of his three teaching appointments goes, it would be idle to suggest that he was successful. Where teaching classical chemistry was concerned, the students were in general unable to follow his methods of thought. But circumstances were wholly different when it came to postgraduate radioactive work directed to experimental determinations. There he made sure there was ample opportunity for discussion, for question and for answer and in general for complete understanding of the point at issue. For elucidation of ideas in those circumstances he was most patient, and when it came to recording results he required the maintenance of a very high standard for logical presentation and clarity of diction. With his demonstrator during a period of concentration of teaching duties, he shared routine responsibilities, so that time was always available to ensure a degree of continuity of research work.

He was elected a fellow of the Royal Society in 1910, and in 1934 the University of Glasgow conferred on him the honorary degree of LL.D.

He married Winifred Moller Beilby in 1908, and her death in 1936 was a grievous loss to him. She was a woman with sound judgment of character and much common sense. Social occasions in their home contributed much mental stimulus and have left me with the happy impression of many games started with intellectual purpose ending in a riot of discursive and witty conversation.

ALEXANDER FLECK

NEWS and VIEWS

Nobel Prize for Medicine for 1956

The Nobel Prize for Medicine for 1956 has been divided between Dr. Werner Forssman, of Bad Kreuznach, West Germany, and Prof. Andre Cournand and Prof. D. W. Richards, jun, both of the School of Medicine, Columbia University, New York. The award has been given for their work on the catheterization of the heart and pathological changes in the circulatory system.

Institute of Personnel Management: New Director

Mr. Leslie Stephens, principal of Fircroft Working Men's College, Birmingham, has been appointed director of the Institute of Personnel Management in succession to Mr. M. B. Forman, who is taking up an appointment with the Staff Department at the headquarters of the National Coal Board, where he will be mainly concerned with staff planning. Mr. Stephens, who is forty-seven, is a graduate of Hertford College, Oxford, and has taken the business administration course at the London School of Economics. Before going to Fircroft Working Men's College in 1946, he was for seven years with the Factory Department of the Ministry of Labour. He is the author of an Occasional Paper (1956) of the Institute, "Employment of Coloured Workers in the Birmingham Area".

Electronic Computing Laboratory of the University of Leeds: Dr. A. S. Douglas

The University of Leeds has recently announced that a Ferranti 'Pegasus' electronic digital computer has been ordered for installation in the autumn of 1957, and that Dr. A. S. Douglas has been appointed director of the new electronic computing laboratory within the Department of Mathematics. The 'Pegasus' is a medium-sized general-purpose computer, capable of adding or multiplying at the rate of about a thousand ten-figure numbers per second, and will be used not only for the researches of scientific and technological departments in the University but also for industrial and commercial organizations in the Leeds region which have problems calling for high-speed and complex calculations. Although this will be the first electronic computer to be installed in Leeds, members of the University already have had considerable experience of the use of the machine which has been available for some time in the University of Manchester and which is the prototype from which the design of the faster 'Pegasus' has been developed. During the past four years members of the Chemistry Department at Leeds have solved many difficult problems of molecular structure by means of the Manchester machine, and similarly in the Department of Textile Industries a problem concerning the drying processes in paper mills has been solved, one set of calculations for which took only 36 minutes on the computer compared with the many months of desk calculation formerly necessary. The computer will cost about £50,000, a large part of which is being met by a grant from the University Grants Committee; the University hopes that industrial and commercial organizations interested in high-speed computing will give additional aid.

Dr. Douglas is on the staff of the University of Cambridge Mathematical Laboratory and is a Fellow and Junior Bursar of Trinity College, Cambridge. He will take up his appointment in Leeds in September 1957, and will be available for consultation during the intervening period while the computer is being installed and the laboratory equipped and staffed.

Journal of Technology

The first number of a new half-yearly *Journal of Technology* was published for the Bengal Engineering College in June. It is regrettable that no statement of editorial policy has been included in this number, although the cover pages include useful and detailed instructions to prospective authors. It is not, however, stated whether the *Journal* is intended to be a medium for the publication of papers from the Bengal Engineering College or whether it is intended to cater for a wider field of authors. On the other hand, it is stated on the cover page that the subject-matter is intended to include original research contributions in science and technology, and this intention is fulfilled in the first number, which includes six papers on original research in electrical engineering, geophysics, civil engineering, applied mathematics and applied mechanics. There are also two letters from the Departments of Chemistry and Metallurgy. The technical standard of the contributions is high, the English is good, except for a few minor points, and there is only a very small number of printing errors. A small page-size, 10 in. by 7 in., has been adopted and columns avoided, while a pleasing contrast has been achieved between the print and the paper. The figures are clearly printed and adequate space has been allowed for these and for the tables. At the end of the number are given about eighty short abstracts of publications in other journals. The value of these would be greatly enhanced if the basis of selection was stated. This is an attractive periodical which deserves to succeed, and which should prove valuable to British readers wishing to acquaint themselves with some of the research work being undertaken in India.

Regional Library Systems of Great Britain

The function and structure of the regional library systems of the United Kingdom, including a section on the support received from the Carnegie United Kingdom Trust and on the work of the National Committee on Regional Library Co-operation, are described in Library Association Pamphlet No. 2, "The Regional Library Systems" (pp. 71; 7*s*., or 5*s*. to members of the Association; 1956), which is a second edition of the pamphlet that first appeared in 1950. Developments since Mr. R. F. Vollans's report on library co-operation in Great Britain was published in 1952 and current problems are discussed in a final chapter, while an introduction directs attention to certain improvements since the first edition was published, notably the general increase in book funds for public libraries and the diminished number of libraries which are borrowing books that should be available in their own stock. Four subject-specialization schemes and two more modest schemes designed to ensure regional self-sufficiency in current British books have made it easier to meet requests for new books, and the existence of the "British National Bibliography" and gradual improvement in the bibliographical training of library staffs have decreased the number of needlessly inaccurate requests. The basic problems remain, much as depicted by Mr. Vollans, and the pamphlet notes certain respects in which the establishment of regional reference libraries is likely to

increase the efficiency of the regional lending-library systems. The necessity for government aid is fully recognized, and, by implication rather than by direct statement, the pamphlet is a further indictment of the Government's inaction in this field and failure to implement the recommendations of the Advisory Council for Scientific Policy. Reference is made to an even more detailed scrutiny of the work of the North Western Regional Library System and of its requirements in that area, which was contained in a report, published this year, by J. F. W. Bryan, L. L. Ardern, G. B. Cotton and A. Glencross.

New Australian Map of the Antarctic

THE second edition of the general map of Antarctica on a scale of 1 : 10,000,000, produced by the National Mapping Office, Australia (Antarctic Division, Department of External Affairs, Canberra), has recently been published. The first edition was published in 1939, and comparison of the two maps shows not only that very many more named features have been added to the latest map, but also that much of the previously unexplored coast (a dotted line in the 1939 edition) has now been filled in. This is particularly noticeable in the larger-scale inset of the Australian Antarctic Territory. The map is clearly and well produced in colour; lettering is in blue and black; mountains are lightly etched in brown; and ice fronts are shown with the date of their latest known position. Political boundaries remain the same as in 1939. The map is obtainable in Britain from Australia House, London, price 2*s*.

Long Ashton Research Station : Report for 1955

STEADY progress in the major activities of the Agricultural and Horticultural Research Station, Long Ashton, is recorded in its annual report for 1955 (pp. 224+12 plates. Published by the University of Bristol, 1956; 15*s*.). Collaboration with the Colonial Office has been further developed by the appointment of two officers, one to work on problems of practical entomology and spraying at centres in the Colonial territories and the other will be concerned with engineering problems. The Section of Pomology and Plant Breeding has so far assembled sixty species towards a working collection of *Ribes* species which will serve as breeding material for improving black-currant varieties. An attempt is also being made to clarify the classification of gooseberry varieties with due regard to the complications caused by widespread virus infection. Experiments have been continued with synthetic growth substances to study their efficiency as thinning agents, for controlling pre-harvest drop and for accelerating ripening in apples. As a result of experiments initiated in 1944, it is suggested that the economic life of blackcurrant plantations, hitherto assumed to be ten years, can be confidently raised to fifteen years under present-day methods of management. Investigations carried out by the Fruit Nutrition Section on the cure of chlorosis of fruit trees by application of iron chelate compounds to the soil have shown that complete recovery from chlorosis during the year of treatment can be obtained by soil application of iron chelates to chlorotic pear trees provided the compounds are thoroughly watered in, or placed near the rooting zone by means of liquid soil injection. It is thought, however, that the method is uneconomic, and it was found that three to four foliar applications per season will also give control of chlorosis. In the Cider and Fruit Juice Section vintage trials of cider and perry varieties have been continued, and a standard method of fermentation combined with sterile bottling has been adopted.

Arterial Arches of Birds

IT has long been realized that the arteries near the heart and in the neck of birds vary very widely from species to species. Fred H. Glenny (*Proc. United States Nat. Mus.*, **104**, 463; 1955) has discussed the modifications of the pattern of the aortic arch system of birds and their significance. He has made a major contribution to this subject during the past sixteen years and has dissected more than 750 species and subspecies. The present memoir considers not only this work but also all that has been reported previously and what is known of the development of these vessels in birds (not a great deal). In the light of this the author has drawn up a classification of the principal patterns encountered with their sub-divisions, and so by means of a series of letters and numbers is able to express the conditions found in the different species in such a manner as to allow of ready reference and comparison. It may be noted, in passing, that the major division is into those with one or two carotid arteries. In his conclusions, he suggests that the Archaeornithes should be placed in the Sauropsida with the Reptilia, "since mere presence of feathers is not sufficient for placing them in close association with modern birds". As commonly understood, however, the Sauropsida includes Reptilia and Aves as opposed to the Theropsida, the Mammalia. This memoir contains a great deal of information in a concentrated form, and constitutes a mine of information for future reference. The eleven figures contain a large number of individual diagrams, and in view of its usefulness it is a pity that many of them are not larger and clearer. Fig. 108*e* is stated to represent the arteries in *Sphenodon punctatus*, but, so far as can be judged, bears little resemblance to the condition in that animal.

Screens for Meteorological Thermometers

THE thermometers used for measuring air temperature and humidity must be at the same temperature as the surrounding air or at the correct wet-bulb temperature. The major source of a difference of temperature between the bulb and the surrounding air is radiation to or from the bulb. A shield must be provided over the thermometers to minimize radiative heat-exchange without impeding the flow of air past the bulbs. The most accurate instrument is the Assmann psychrometer, consisting of two small thermometers, one dry-bulb and one wet-bulb, in narrow parallel tubes made of highly polished metal through which a stream of air is drawn by a fan driven by a clockwork or, better, an electric motor. The Assmann psychrometer is expensive, and the screen most used is the "Stevenson" screen, which is a louvred box painted white and relatively large in comparison with the thermometers which it houses. The Meteorological Service of the West German Republic has recently made experiments (*Ber. Deutsch. Wetterdienst*, **3**, No. 19; 1956), to see if a screen cheaper and more easily installed than the Stevenson screen would be satisfactory for use at auxiliary meteorological stations at, for example, farms and in forests. The screens used were four in number: large, medium and small Stevenson-type screens; and a "shade tube" (*Schattenhulse*) made of polished aluminium foil 0·2 mm. thick, 5 cm. in diameter and 45 cm. long,

open at the ends, with a thermometer 32 cm. long fixed along the axis, and suspended so that it could be turned for the tube to be along the wind. The readings of the screen thermometers were checked against those of an Assmann psychrometer. 333 separate trials were made over a period of nearly four months in the late summer and autumn of 1953. It was found that the tube gave the best overall comparison with the Assmann readings, followed by the small screen; then, with an appreciable interval, the large screen; and finally, the medium screen. The aluminium tube came out best under all types of weather and change of temperature. It was best even in calm sunny weather because, though the tube is heated a little above air temperature, the thermometer has better ventilation than the thermometers in the screens, which also are heated above the air temperature.

British Society of Rheology: Officers

The following have been elected officers for 1956–57 of the British Society of Rheology: *President*, Prof. J. G. Oldroyd; *Honorary Secretary*, N. Wookey (52 Tavistock Road, Edgware, Middlesex); *Honorary Treasurer*, D. W. Jopling; *Honorary Editor*, Dr. E. W. J. Mardles; *New Members of Committee*, C. C. Mell and Dr. J. C. Vernon.

Royal Society of Tasmania: Officers

The officers for 1956 of the Royal Society of Tasmania are as follows: *President*, Sir Ronald Cross (Governor of Tasmania); *Vice-Presidents*, F. C. Wolfhagen and Dr. W. L. Crowther; *Council*, Prof. T. Hytten, C. Bisdee, Dr. D. Martin, Dr. W. V. Teniswood, Prof. S. W. Carey and L. W. Miller; *Honorary Secretary*, Dr. W. Bryden (Tasmanian Museum and Art Gallery, Box 416B, G.P.O., Hobart); and *Honorary Treasurer*, G. E. Hale.

The Night Sky in November

New moon occurs on Nov. 2d. 16h. 43m., U.T., and full moon on Nov. 18d. 06h. 44m. The following conjunctions with the Moon take place: Nov. 4d. 10h., Saturn 1° N.; Nov. 13d. 12h., Mars 7° S.; Nov. 27d. 01h., Jupiter 6° N.; Nov. 29d. 17h., Venus 4° N. In addition to these conjunctions with the Moon, Venus is in conjunction with Spica on Nov. 18d. 18h., Venus being 4·2° N. There will be a total eclipse of the Moon on November 18, partly visible at Greenwich. The Moon enters penumbra at 4h. 00m. and umbra at 5h. 03m.; totality begins at 6h. 08m. and ends at 7h. 27m. Moonset at Greenwich is at 7h. 32m. Mercury is too close to the Sun for observation. Venus is a morning star, rising at 3h. 15m., 3h. 55m. and 4h. 40m. on November 1, 15 and 30, respectively; its distance from the Earth increases from 107 to 123 million miles during the month. Mars is visible during the evenings, setting at 1h. 50m., 1h. 25m. and 1h. 05m. on November 1, 15 and 30, respectively; it continues to recede from the Earth, its stellar magnitude decreasing during the month from −1·3 to −0·4 and its distance from the Earth increasing from 53 to 73 million miles. At the beginning of the month Mars is north of ψ Aquarii, and is moving eastwards, passing into Pisces on November 22. Jupiter rises at 2h. 40m., 2h. 00m. and 1h. 05m. at the beginning, middle and end of the month, respectively, and is near β Virginis; its stellar magnitude is −1·4 and its distance about 550 million miles. Saturn is too close to the Sun for observation, being in conjunction on November 27. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Nov. 11d. 23h. 06·6m., 44 Aqr. (*D*); Nov. 14d. 19h. 28·3m., 51 Psc. (*D*); Nov. 22d. 4h. 15·1m., 162 *B*. Gem. (*R*). *D* and *R* refer to disappearance and reappearance, respectively. The Taurid meteors are active during November 1–16; conditions are expected to be favourable, the radiant is near R.A. 3h. 36m., Dec. 14° N. The Leonid meteors are active during November 15–20, but conditions are unfavourable for observation.

Announcements

Prof. Sydney Chapman has been appointed Gauss professor of geophysics of the Academy of Sciences at Göttingen for 1956–57. This professorship was founded in connexion with the celebration of the Gauss centenary. The Gauss professor for 1955–56 was Prof. E. Artin, of the University of Istanbul, who was unable to be in Göttingen during that year, and s also there during the present session.

The Science Committee of the Society for Cultural Relations with the U.S.S.R. is considering the possibility of arranging a Russian-language school for British scientists to be held in Leningrad during 1957. It would be for scientists with some knowledge of Russian, would be staffed by Soviet teachers, and would last twelve days plus travelling time, six days each way, with hostel accommodation. Sight-seeing would be arranged. The overall cost would be about £80, plus 25 roubles a day spending allowance inside the Soviet Union. Those interested should write to the Society at 14 Kensington Square, London, W.8.

The Ministry of Agriculture, Northern Ireland, has awarded the following scholarships: *Agricultural Science*, D. L. Armstrong, S. R. J. Bingham, W. M. Dunlop, H. R. Kirkpatrick, D. J. McCormick and J. S. Smith (four years at The Queen's University, Belfast); *Dairy Science*, A. G. Foote (four years at the University of Reading) and R. S. Shannon (two years at the University of Nottingham School of Agriculture, Loughborough); *Forestry*, W. D. Fyffe (three years at the University of Edinburgh), and J. M. Elliott (three years at the University of Aberdeen).

The Gas Council awards each year five research scholarships to students who have recently graduated in physics, chemistry or engineering, and the scholarships for this year have been announced as follows: R. Salter (Department of Inorganic and Physical Chemistry, Oxford), mechanisms of vibrational activation of hydrocarbon molecules by ultrasonic dispersion measurements on vapours; A. Wint (Department of Chemical Engineering, Cambridge), interfacial transfer phenomena; J. W. Arnold (Department of Chemical Engineering, Imperial College of Science and Technology, London), energy exchange in polyatomic molecules, with particular reference to hydrocarbons; P. Owens (Department of Chemical Engineering, Birmingham), high-pressure reactions between oil and hydrogen; and D. H. Grant (Department of Chemistry, Glasgow), a fundamental chemical investigation within the field of polymer degradation reactions.

Erratum. In the communication entitled "Interior Deformation Markings in Copper Fatigue Specimens" by D. S. Kemsley in *Nature* of September 22, p. 653, col. 2, par. 3, line 6, for "632,400 c./min." read "632,400 cycles at 21 c./min.".

TWO NEW NATURE RESERVES IN ENGLAND

THE Nature Conservancy has announced the establishment of the following two new nature reserves in England: Morden Bog, near Wareham, Dorsetshire; and Wren's Nest, Worcestershire.

Morden Bog reserve is about a mile north of Wareham and is close to the Conservancy's research station at Furzebrook. The northern part of the reserve consists of undulating heath and a small pine wood; in the drier parts there is considerable regeneration of Scots pine. In the south of the heath in a shallow lies Old Decoy Pond. The present declaration covers an area of 168 acres and has been made under a long lease from the Drax Estate. The Bog is a unique variant of southern heathland, and carries a rich flora and fauna, both vertebrate and invertebrate. It shares many characteristics with the heaths of Purbeck and the New Forest, including some of the rarities, for example, a grasshopper *Chorthippus vagans* and an ant *Formica picea*, which nests in sphagnum bog. Two of the insects—a digging, predatory wasp *Pompilus rufus* and an ant *Formica pratensis*—are not known to occur elsewhere in Britain. Morden Bog is the most interesting remnant of the great heaths which once stretched from Dorchester to Wareham and were described in Thomas Hardy's novels as "Egdon Heath". Freedom from disturbance and the most stringent precautions against fire are essential for the reserve. Access is by permit only, applications for which should be made to the Conservancy's Regional Officer for the South West at the Furzebrook Research Station, Wareham, Dorset.

The declaration of Wren's Nest as a nature reserve has been made possible by the co-operation of the local authority owning the land, the Dudley County Borough, and negotiations are almost completed with the Coseley Urban District Council for the addition to the reserve of the northern part known locally as Mons Hill. Wren's Nest is internationally famous as a classical geological exposure of Upper Silurian rocks. The Wenlock Limestone (known also as the Dudley Limestone) has yielded a magnificent fossil fauna of probably well over three hundred species, all in a state of perfection such as no other locality in Britain exhibits. This includes the trilobites, shells, corals, sea-lilies and other marine life of the time that the strata were laid down in the sea, which is estimated to be some 330 million years ago. Fossils have been described and figured here since Dr. Plot's work of 1686. Specimens from Wren's Nest are preserved in museums all over the world, and there is a fine collection of them in the Dudley Public Library.

The area is a wooded hill with a broad flattened top (now playing fields) bounded by precipitous and deep artificial ravines which descend into great and steeply inclined caverns. The structure of the hill is a peculiar sharp anticline or arch of the rock strata, which, unlike most anticlines in Britain, can be seen to make a topographical feature. Similar structures are found concealed below ground, protruding into the Staffordshire Coalfield in the north, and Wren's Nest can help in assessing these features. The local limestone was largely won for the iron smelting of the nineteenth century and the early years of the present century. The ravines mark the surface workings, and the deep caverns record the underground exploitation, the limestone being removed by an underground canal which pierces the hill. The reserve is accessible to the public; but permission must be obtained to carry out scientific work, applications for which should be made to the Geologist at the Nature Conservancy headquarters, 19 Belgrave Square, London, S.W.1.

SALT UPTAKE IN PLANTS

THE process of mineral salts uptake by plants is being investigated independently in several laboratories in Britain at the present time. It was appropriate, therefore, that it should be the subject of a session in Section K (Botany) at the British Association meeting this year at Sheffield.

Opening the discussion, Dr. J. F. Sutcliffe (Department of Botany, King's College, London) emphasized the importance of a satisfactory knowledge of the salt relations of plant cells as a basis for an understanding of the processes of absorption and transport in intact rooted angiosperms. His contribution and that of Dr. A. B. Hope (present address: Botany School, Cambridge) were concerned with the mechanism of salt uptake at the cellular level.

From the work of a number of investigators with various experimental materials the following view of salt absorption in a vacuolated plant cell has emerged.

There is an initial uptake of ions by diffusion and exchange through the cell wall and outer protoplasmic membrane into the bulk of the cytoplasm, where they are held by the establishment of Donnan equilibria and by adsorption on to protoplasmic constituents. This physical phase of uptake, which is limited in extent, does not depend directly on an expenditure of metabolic energy. Most of the ions taken into the cell are afterwards transferred across an inner membrane (the tonoplast) and accumulated in a free state in the vacuole. Since the tonoplast is rather impermeable to exchange and diffusion, and, moreover, since movement frequently occurs against a concentration gradient, it is evident that a supply of respiratory energy is involved.

It is generally agreed that active transport takes place by the operation of some form of a 'carrier' mechanism. This probably involves the formation of complexes between the ions and some organic constituents of the cell. These complexes move across the membrane and are broken down on the inner side to release the ions and re-form the original carrier molecules. Although a mechanism of this general kind, with suitable elaboration, will explain the facts that are known about salt accumulation, the precise details of the process have not yet been established. In particular, suitable carrier molecules have not yet been identified with certainty, and it

is not clear how energy is incorporated into the system.

Against this background, Dr. Sutcliffe discussed various problems of salt accumulation presented by vacuolated cells of storage tissues. The development of an absorptive ability in cells of dormant organs under the influence of experimental treatments has been related to activation or synthesis of carrier molecules. Recent work of Dale and Sutcliffe (unpublished) has indicated that the inability of freshly cut slices of red beet root tissue to accumulate potassium ions from aqueous solutions of potassium chloride is caused indirectly by the non-functioning of a chloride-transporting mechanism rather than by lack of potassium carriers.

Non-growing cells of storage tissues have a limited ability to accumulate salts and, as uptake proceeds, the rate of absorption diminishes. Evidence has been obtained that this is associated with a decrease in the activity of the transport system rather than to an increase in the rate of outward movement of salt. It was suggested that the final stage in active transport is a spontaneous breakdown of the ion-carrier complex which proceeds so long as the free energy of the system is thereby diminished. With an increase of internal concentration, the complex breaks down less readily, until, when the tissue becomes saturated, all the carrier molecules remain in a combined form, and absorption ceases.

Cells of storage tissues possess the power of discrimination between different ions, and this ability has been examined with respect to the alkali metal ions. In terms of a carrier hypothesis, it is proposed that selective absorption depends on the preferential binding of certain ions by the transporting molecules. This property may prove useful in the ultimate isolation and identification of the substances involved, which is now to be attempted. Preliminary experiments have indicated that particulate fractions from red beet and potato tissues also bind some alkali cations in preference to others, and it seems possible that mitochondria may be a rich source of binding substances similar or identical to those responsible for ion transport in the plant cell.

Dr. Hope discussed fully the processes of physical uptake in vacuolated cells. He raised the question as to which structures in the cell determine the amount and rate of uptake of salts. The cell wall, outer cytoplasmic surface, bulk of the cytoplasm, cytoplasmic inclusions and the tonoplast were considered in turn. Some recent evidence from tracer studies with radioactive isotopes on beet and carrot tissue (Hope, unpublished) indicates the absence of a membrane resisting the exchange-diffusion of ions at the surface of the cytoplasm. It is considered likely that the cytoplasm acts as a Donnan phase with an immobile anion concentration of 100–300 m.equiv./l. The effects of the sign and valency of the supplied ions and the *p*H of the medium on the equilibrium concentration of ions in such a phase were discussed.

It has been established that some ions are bound in cell particles in a relatively non-exchangeable form. This may perhaps be associated with the presence of lipoprotein lamellæ which have been revealed by electron microscope studies. Physical uptake was estimated to account for about one-hundredth of the total inward flux during active accumulation.

Dr. L. J. Middleton (Agricultural Research Council Field Station, Compton, Berks) read a paper on "Interactions in the Transport of Ions through Whole Plants". He said that whereas in studies of salt uptake at the cellular level two phases are commonly distinguished, in intact plants a further process may be examined, namely, the passage of ions into the xylem. There have been some claims that salts may move passively into the conducting elements in the transpiration stream, but the bulk of transport appears to be under metabolic control.

In an experiment designed to discriminate between passive and active movement of salt into the xylem of young barley plants, use was made of the fact that ions are known to compete with one another in the physical and metabolic stages of uptake at the cellular level. Experimental work with disks of storage tissue has shown, for example, that strontium reduces the physical uptake of rubidium, but does not significantly depress the active absorption of these ions. In whole plants, the situation is apparently more complex since results are influenced by the salt status and transpiration-rate of the plant. It seems that salt content is a major factor controlling the gross number of ions absorbed, whereas transpiration-rate is important only when the salt content of the plant is high.

The presence of strontium reduced both the uptake of rubidium and its transport into the shoot in high-salt plants, but had no significant effect in either case with low-salt plants. It was concluded that, in the latter, active secretion of rubidium into the xylem predominates, whereas in high-salt plants physical processes attain some importance.

Finally, Dr. J. L. Harley (Department of Botany, Oxford) spoke on "Factors affecting Salt Uptake by Beech Roots". He suggested that since explanations of the ecological distribution of plants often depend on views concerning their ability to absorb nutrients from the soil, the impact of physiological studies of salt uptake on ecology should be considered. As a phase in research, conditions not met in the field are frequently employed in laboratory work. Convenient temperatures, oxygen tensions and salt concentrations are used rather than ecologically probable conditions. Using results obtained with beech mycorrhizas sampled from natural habitats, the importance of laboratory work to field studies has been examined.

The effects of a range of temperature, oxygen tension and salt concentration on the uptake of various ions by beech mycorrhizas have been studied. High values of Q_{10} were obtained for uptake over a temperature-range from near zero to 15° C. For potassium concentrations expected in the soil an upper soil temperature of 20° C. limits the condition in which beech mycorrhizas are effective absorbing organs.

Potassium is lost from mycorrhizal tissue into distilled water or dilute solutions containing salts when the oxygen tension falls below 3 per cent. The most efficient absorption of both anions and cations occurs in gaseous mixtures containing 10–20 per cent of oxygen. The oxygen concentration found in the soil horizons in which the roots grow naturally has not been observed to fall below 19 per cent by volume. It may be noted that beech is a plant of dry soils, intolerant of water-logged or heavy soils.

When salts were supplied at a high concentration (10–100 m*M*) diffusion of ions through the tissues of the mycorrhiza was found to be an important phase in the process of absorption by the host. At low concentrations (0·1–1·0 m*M*) diffusion of salts through the fungal tissue was negligible. Using a range of phosphate concentration and temperature,

and by applying metabolic inhibitors, it was shown that movement of phosphate through the fungal layer into the host plant was probably through the living cells of the fungus, when the material was suspended in dilute solutions.

It was concluded that physiological studies on salt uptake have a contribution to make to ecology, provided that due allowance is made for the differing conditions in the laboratory and in Nature.

J. F. SUTCLIFFE

STATISTICAL MECHANICS OF TRANSPORT PROCESSES

INTERNATIONAL COLLOQUIUM

THE International Union of Pure and Applied Physics arranged a five-day conference at Brussels during August 27–31, which was attended by approximately a hundred scientists who are interested in the statistical theories of irreversible processes. Twenty years earlier, this subject would neither have been worth a conference on its own nor would it have been accredited the title of 'statistical mechanics', which was reserved for the theory of equilibrium. The new name and the attendance of the conference are indications of the progress made within two decades.

The foremost subject of the conference was the problem of reconciling macroscopic irreversibility with the reversible character of molecular mechanics, Newtonian or quantal. The problem is old and its discussion earlier than 1910 is summarized in the famous article by P. and T. Ehrenfest which is even now not out of date. The discussion has only recently gained in importance after the theory of transport processes had increased its scope of validity. In technical terms, the problem put before the conference has the form of deducing the collision equation of Maxwell and Boltzmann or its quantum-mechanical analogue from the Liouville equation or the principles of quantum mechanics, respectively. In considering this subject it was assumed that both, premises and conclusion, are well established, but that the intermediate steps of the deduction are in need of clarification.

It was generally agreed that the validity of the Boltzmann equation depends upon some kind of coarse graining of the distribution in full-phase space. There was, however, no agreement with respect to the method of coarse graining. It was argued that irreversibility is the result of time-smoothing of phase-space distributions and that this process of time-smoothing can and should also be applied in the quantum mechanical theory. An alternative (not necessarily contradictory) view was put forward, according to which irreversibility arises asymptotically in the limit of 'large' time-intervals after motion started from well-defined initial conditions. These are by no means the only current views on the nature of irreversibility; but they can claim the best foundation in molecular dynamics.

It would appear that the main progress in this old discussion consists in replacing guesswork by hard-and-fast mathematical results. It was emphasized in the discussion—very much to the surprise of part of the assembly—that irreversibility is, by necessity, limited to the time interval between two characteristic times, that is, the molecular relaxation or correlation time and the period of a Poincaré cycle.

In the quantum mechanical theory, interest was primarily concentrated on the assumption of 'randomness' which has to be made in the course of the deduction. Whereas previously this assumption was, without questioning, interpreted as the necessity of taking an average with respect to the phases of the wave functions at all times, a somewhat more critical attitude emerged in recent years. In the conference it was shown that the phase-averaging can be avoided and that there are various different ways of deducing irreversibility in statistical quantum mechanics.

Another subject on the agenda concerned the fundamental theory of those transport processes—in particular processes in liquids and solids—to which the Boltzmann equation cannot be applied. Contributions to this subject were—by its nature—less systematic and of greater originality and perhaps of greater importance for future research. To mention an example, the use in this field of electronic computation was shown; it is employed for solving a cumbersome problem in the dynamics of molecules but assumes peculiar significance as standing halfway between theory and experiment. Whereas measurements of transport coefficients reveal only an average over a large number of samples, the electronic computer produces the samples themselves and shows how their fluctuating properties are smoothed out with increasing numbers.

As another example, the use of elastic rigid spheres as models for molecules should be mentioned. This is apparently a somewhat trivial matter. It was, however, shown that the mathematics of this model have some entirely unexpected features and are likely to be of importance in handling more realistic models of molecules.

Apart from the basis of the theories, the conference had obviously to deal with their application to specific phenomena. So far as transport processes in gases are concerned, this requires appropriate solutions of the Boltzmann equation. A number of papers were read showing that these solutions are not obtained by routine procedures but by careful mathematics and plenty of physical intuition. A wide variety of systems other than gases were considered; contributions included thermal conduction in solids and liquids, relaxation of molecular oscillations, transport of charge and energy by electrons in metals, transport processes in liquid helium, viscosity of electrolytes, fission of uranium and, in some detail, the statistical hydrodynamics of turbulent flow. In these talks and discussions the progress in the theory of irreversibility was demonstrated beyond doubt.

Apart from transport processes, the modern theory of irreversibility is concerned with the extension of thermodynamics to non-equilibrium conditions. During the conference plenty of time and attention were given to the principle of minimum entropy production, which has been widely discussed and would, if fully established, have a wide range of applicability. So far, the significance of this principle has not yet been clarified. Some of the speakers presented deductions of the principle depending upon clear-cut premises; on the other hand, instances were produced in which the principle is not strictly valid. Various alternative aspects of off-equilibrium thermodynamics were presented. Conclusive new results were not offered; but there is increasing

interest in the subject. Finally, a fair number of experimental papers were read, largely concerning measurements of the diffusion coefficient or thermal diffusion ratio of mixtures.

This colloquium differed in various respects from meetings of a similar kind. One of its characteristics was the interest shown in the consistency rather than in the result of deductions, an attitude frequently dismissed as 'academic'. Speakers were unanimous in their attempts at clarifying the assumptions underlying their own and other speakers' arguments, concentrating on the physical aspects of the problem and avoiding any form of mathematical pedantry. This again is an exceptional attitude, since there is a widespread habit of adorning dubious physical assumptions with a wealth of good mathematics.

Time provided for discussions was ample; speakers could state their case without any fear of being cut short by a harassed chairman. Discussions were conducted as a free exchange of views, not necessarily perfect views, and without the purpose of scoring debating points. As a consequence, subjects of interest were talked over in their widest aspects and by a large number of speakers, conveying thorough clarification and stimulating ideas to the listeners.

The theory of transport processes emerges from this colloquium as a new branch of statistical mechanics which should have a status comparable with equilibrium theory.

This new branch has to a considerable extent been initiated by the work of H. Falkenhagen, J. G. Kirkwood, L. Onsager, G. Uhlenbeck and J. Yvon, who were among the distinguished visitors attending the colloquium. Its success was largely due to Prof. I. Prigogine, partly in his capacity as organizer and even more by the contributions made by him and his school. Thanks are due to the Université Libre de Bruxelles for hospitality and to the American Air Force for generous help.

R. Eisenschitz

CHEMICAL ENGINEERING IN THE COAL INDUSTRY

CONFERENCE AT THE COAL RESEARCH ESTABLISHMENT, NATIONAL COAL BOARD

THROUGHOUT the world there has been a renaissance in the application of scientific methods to coal and its treatment. This is not the result of a desire for science for its own sake; but is directly connected with the world-wide problems of energy supply and resources.

A notable feature of this new research work is the increasing application to the coal industry of new chemical engineering techniques developed by other progressive industries. The time seemed ripe, therefore, to bring together the research workers in different countries, from industrial and university laboratories, interested in this new outlook on coal.

An international conference on "Chemical Engineering in the Coal Industry" was therefore organized by the Coal Research Establishment at Stoke Orchard of the National Coal Board. It was held during June 26–29, and was attended by a hundred representatives from Britain and overseas.

Mr. A. H. A. Wynn (scientific member, National Coal Board) in his address of welcome to the delegates, pointed to the fact that all estimates of energy requirements, including those of the U.S.S.R., indicate that the economy of almost every country over at least the next twenty or thirty years will depend fundamentally on the prosperity and technical progress of the coal industry. Mr. Wynn underlined the great variety of coals produced in Britain and the different end-uses to which they are put. It is in the subject of efficient use, particularly of those coals not of the highest quality, that the chemical engineer can play an important part. Some of the economic problems of Western Europe, in his opinion, arise from the insufficient application of modern science to the basic industries.

Three chief problems were considered at the conference: the modification of coal to render it suitable for subsequent processing; the briquetting of coal; and the treatment of by-products resulting from new processes. A remarkable feature of the conference was that, although all the countries represented are interested in these three subjects, their interests are to a large extent directed towards different objectives. Whereas the aim in Great Britain is the production of efficient, solid smokeless fuels, in France the aim is the improvement of metallurgical coke. For both purposes, however, the carbonization of high-volatile coals in fluidized beds shows much promise. Again, there is a parallel of interests in Great Britain and Germany in the production of carbonized briquettes from those coals which are not normally considered suitable for carbonization by traditional methods. In Britain the objective is again the production of smokeless fuels; but Germany considers the process to be promising as a method of producing regular-sized hard coke for metallurgical purposes.

The conference was organized into four technical sessions, which reviewed the following topics: (*a*) the modification of coal properties by oxidation; (*b*) the briquetting of small coal; (*c*) the carbonization of powdered coal in fluid beds; and (*d*) the utilization of the by-products from new carbonizing processes. Papers were presented on both fundamental and technical aspects of these subjects.

Modification of Coal Properties by Oxidation

A paper entitled "The Controlled Oxidation of Coal", which was presented by M. A. F. Boyer (Centre d'Études et Recherches des Charbonnages de France), described some recent work on the rates of oxidation, the activation energies involved, and the depth of penetration of the oxidation reaction into coal particles.

In the production of carbonized briquettes, marked fusion and swelling of the coal is disadvantageous; but these characteristics may be modified or destroyed by a number of methods, principal among which is oxidation. The addition of as little as 1 per cent of oxygen, for example, to the coal can eliminate these adverse effects. However, the fundamental changes which occur on oxidation, particularly the mechanisms of the chemical changes, are as yet not understood. Dr. D. W. Gillings (formerly of the Coal Research Establishment, National Coal Board) pointed out that one effect of oxidation is to decrease the plasticity of the coal. M. Boyer believes this to be an unimportant effect, and considers that the important effect of oxidation is to change the shrinkage characteristics of the coal on carbonization. Dr. J. Bronowski (Coal Research Establishment)

pointed out that most explanations have been centred on the amorphous constituent in coal, but that oxygen can also act on the organized graphitic structures in coal, and that further insight into the process should be gained by studying the bonding of these graphitic layers. Mr. E. H. Williams (Coal Research Establishment) directed attention to the fact that the oxidation process may take different courses with different coals, and illustrated his point by showing the differing rates of oxidation in coals of different volatile contents.

The second paper at this session, entitled "Fluidized Oxidation of Coal", concerned the design and operation of a pilot plant for the oxidation of coal at the Coal Research Establishment, and was presented by Dr. G. I. Jenkins. This plant, which operates on the dense-phase fluidized principle, has a throughput of 1 ton per hr. It is composed of four main sections: (*a*) coal grinding and drying; (*b*) hot gas supplies; (*c*) control instruments; (*d*) reactor columns. The plant is fully automatic and is equipped with recording and control instruments for bed temperature, gas flows and temperatures, oxygen concentration of ingoing and exit gases, bed-level and coal feed. Coal has been oxidized at a number of different temperatures up to 400° C., using gases with oxygen concentrations ranging between 10 and 21 per cent. Other variables investigated are distribution of coal-size and contact time. From the results, the heat of the oxidation reaction at a series of temperatures has been deduced and found to be in the range 50 B.Th.U./lb. at 250° C. to 200 B.Th.U./lb. at 375° C. In the discussion, Mr. T. Kennaway (Simon Carves, Ltd., London) described an alternative method of dilute-phase fluidized oxidation, for which he claimed simplicity of construction and of operation. Dr. Jenkins considered, however, that the dense-phase method is to be preferred because it allows more flexibility in the control of variables.

Briquetting of Small Coal

The second session opened with a paper by Dr. W. Reerink (Steinkohlenbergbauverein, Essen) entitled "Investigations into the Carbonization of Briquettes in Germany". The briquettes were designed to replace coke used in blast furnaces and cupolas. In the preparation of the briquettes from powdered coal, use is made of a special binder (*Teerpechschmelze*) applied in liquid form to the coal. This special binder is similar to a 'cut-back' pitch in that it is prepared by adding certain aromatic oils to pitch. Such a mixture, Dr. Reerink claimed, has improved properties of wetting the coal, and hence it leads to a reduction in the weight required. Dr. Kurt Baum (Kurt Baum and Co., Essen), in discussion, emphasized the need to accelerate the carbonization of the briquettes, which at present takes more than five hours. Success in this respect requires the design and adoption of continuous processes instead of traditional batch-wise methods, and attention was directed to work in progress on this subject at the Coal Research Establishment. The potential importance of the use of carbonized briquettes in furnace and foundry work was emphasized. A demand has always existed for a close-sized reactive hard coke for this purpose, and the development of suitable briquettes would meet this.

The Coal Research Establishment's work on briquetting at elevated temperatures was described in a paper by Mr. D. H. Gregory, entitled "Hot Briquetting". This work was undertaken with two objects in view. First, since the briquetting stage may follow one of pretreatment from which the powdered coal is delivered hot, it is possible to conserve heat between pretreatment and carbonization. (It also has the advantage that there is a saving in pitch, because the coal itself becomes plastic and acts partly as a binder at these temperatures.) The second object was the briquetting of chars from fluidized carbonization, and for this purpose the binder used was a coal-and-pitch mixture. This mixture eliminates many of the difficulties experienced in hot briquetting by extending the range of temperature over which the coal remains plastic. There is evidence also that the resulting briquettes may be smokeless. A somewhat similar process was described by Ir. G. Kardaun (Staatsmijnen in Limburg, Netherlands), in which a high-volatile coal is used as a binder for a low-volatile coal.

Carbonization of Powdered Coal in Fluid Beds

The first paper read at the third technical session was a joint contribution entitled "A Study of Semi-Carbonization in a Fluid Bed", by P. Foch and A. Peytavy (Centre d'Études et Recherches des Charbonnages de France). This paper described their experience in operating a fluidized carbonizer having a throughput of one ton per hour. The plant has been operated chiefly around two temperatures, 500° C. and 800° C., with the object of producing a char from high-volatile coals, suitable as a blending material in the production of metallurgical coke. The two chief problems outlined by the authors were those of introducing the necessary heat at a rate in keeping with the high throughput of the plant, and of suppressing the entrainment of fine coal and char dust in the gases, where they create acute difficulties in the operation of the by-product recovery system. Mr. J. Owen (Coal Research Establishment, National Coal Board), in discussion, referred to fundamental work carried out at the Coal Research Establishment on the measurement of the heats of carbonization (Millard, D. J., *J. Inst. Fuel*, **28**, 345–351; 1955; *Nature*, **174**, 1099; 1954), and described a new method whereby similar results can be obtained from the fluid carbonizing plant itself. The results showed a very steep increase in the endothermic heat of reaction at temperatures between 600° C. and 700° C. Dr. Bronowski followed this up by showing that operation at temperatures around 500° C. and around 800° C. is much more favourable from the point of view of heat requirements than operation in the temperature-range between these values; there the heat requirements are at a maximum near 700° C.

Several speakers emphasized the importance of separation of the entrained dust from the by-product stream, and the wider importance of efficient by-product recovery, since the by-products are of vital importance to the economics of the process.

The second paper presented at this technical session was entitled "The Study of Tars obtained in Fluidized Carbonization", and the authors, Dr. G. H. Watson and Mr. A. F. Williams (Coal Research Establishment, National Coal Board), gave an account of the characteristics of a tar obtained by the low-temperature carbonization of a coal (Coal Rank Code 902) in a prototype 2-in. diameter fluid-bed carbonizer. While not an exhaustive examination (the amount of tar available was only 2 kgm., and examination was com-

plicated by the thermal instability of the tar), the study afforded much information on the constitution of the principal chemical types. In the discussion, Dr. R. J. Morley (Carbonization Department, National Coal Board) pointed out that the constitution of the tar described resembles that of a vertical retort tar, while Dr. H. Bondy (Coalite and Chemical Products, Ltd., Chesterfield) remarked on the differences between this tar and that obtained by the coalite process. Two remarkable features of the tar are that it contains a disproportionate amount of high-boiling phenols and of high-boiling neutral oils.

Utilization of the By-Products from New Carbonizing Processes

Only one paper was read at the final technical session. It was a contribution by J. L. Sabatier (Charbonnages de France, Houillères du Bassin de Lorraine) entitled "Industrial Treatment of Low-Temperature Carbonization Tars". In M. Sabatier's absence, the paper was presented by J. M. Deruelle of the same organization. This paper described the industrial-scale refining of tars obtained from French experimental carbonization plants operating in the temperature-range 500°–700° C. The treatment is conventional and consists of a primary distillation into selected fractions which are further refined by extraction, crystallization or further distillation. The tar yields 10 per cent of phenolic compounds, 60 per cent of oils and 30 per cent of pitch. The principal phenolic bodies produced for marketing are phenol, mixed *m*- and *p*-cresols and 1-2-4, 1-2-5, and 1-3-5 xylenols. Market development is still in progress and will undoubtedly lead to more exhaustive refining of the tar.

In the discussion of the low-temperature tars described, the ease with which the tars may be oxidized to form resinous and pitch-like materials was emphasized, and this was related to earlier papers on the oxidation of coal. This brought out the importance of investigating carbonization techniques in which the heat for carbonization is introduced by methods other than partial combustion of the coal and char in the carbonizing vessel.

Dr. D. McNeil (Coal Tar Research Association) emphasized that the by-products from fluidized carbonization must be the subject of intensive research and that outlets differing from those for conventional tars must be developed.

In his closing address, Dr. Bronowski summarized the discussions and drew some general conclusions. He pointed out that the coal industry, like other traditional industries, is still reluctant to adopt multi-stage processes. The basic cost of handling the raw material in and out of a plant is now so high, however, that an additional stage adds relatively little to the cost of a process. It is essential to base new stages and processes on a scientific study of the fundamental mechanisms by which the chemical and physical properties of coal are changed. The conference showed that all the nations taking part had reached much the same point in these fundamental studies; but they were not all equal in their readiness to take these scientific findings to the pilot scale and to develop them into industrial processes. If we are to benefit from the advances in coal science, we must now concentrate a major effort on development.

The conference was followed by an open day on Friday, June 29, when about 360 guests viewed the experimental work of the Establishment.

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

REPORT FOR 1955

ALTHOUGH much work had already been done by an interim organization, the European Organization for Nuclear Research (C.E.R.N.) came formally into being only in September 1954. The first annual report, covering the period to the end of 1955*, describes in some detail the substantial progress which has been made. It will be recalled that there are twelve member States: Belgium, Denmark, France, the German Federal Republic, Great Britain, Greece, Italy, the Netherlands, Norway, Sweden, Switzerland and Yugoslavia. Each pays contributions roughly according to its national income, the proportions ranging from 23·8 per cent by France and the United Kingdom to 1·79 per cent by Norway. The main aim is to produce those major experimental facilities for pure nuclear research which are too costly for many, if not all, of the member States to provide for themselves, and the present programme includes the design and construction of a 25-GeV. proton synchrotron and a 600-MeV. synchrocyclotron. The governing body is the Council, composed of delegates of member States and assisted by a scientific policy committee with eight members, selected for their qualifications without regard for nationality. A finance committee, with national representation, guides the financial administration.

The present president of the Council is Sir Ben Lockspeiser, and the director-general is Prof. C. J. Bakker, who succeeded Prof. F. Bloch in September 1955 on the latter's return to Stanford University, California. Prof. Bakker's leading collaborators are J. B. Adams (proton synchrotron), W. Gentner (synchrocyclotron), L. Kowarski (scientific and technical services), P. Preiswerk (sites and buildings), C. Møller (theoretical physics) and J. Richemond (administration). The laboratories are under construction on a site provided by Switzerland, at Meyrin, near Geneva. Most of the staff are working in temporary laboratories in Geneva, although a few have already moved to Meyrin. The theoretical physicists are at present centred in Copenhagen. Much of the design of the accelerators and buildings had been established under the interim organization, and the period under review has been occupied in pursuing these plans. The original programme called for the completion of the synchrocyclotron during 1957 and the proton synchrotron during 1960. It is expected to be maintained.

Proton Synchrotron. The main parameters of the large machine were settled at the end of 1954, and no important alterations have been made since. The radius will be 100 m., and the magnet will consist of a hundred separate units with a total weight of steel of 3,200 tons. Protons will be injected at 50 MeV. from a linear accelerator, and the final energy will be 25 GeV. at the maximum magnetic field of 12,000 gauss. The principle of alternating gradient (or 'strong focusing') will be used, each magnet unit having focusing and defocusing portions. This system is now well understood, following much theoretical and experimental work at the Organization and at the Brookhaven National Laboratory in the United States, where a similar machine is being built.

* European Organization for Nuclear Research, C.E.R.N. First Annual Report. Pp. vi+66. (Geneva: C.E.R.N., 1955.)

These two projects, which were the first of their kind, are in roughly comparable states of progress, and there has been close collaboration between the two groups. For example, a large electron model, a major project in itself, was built at Brookhaven as an analogue of a large alternating-gradient machine, and the results obtained with it have benefited both projects. There has been interchange of staff between the two laboratories.

The magnet units have to be very accurately made to a design which takes much careful work to establish, and the magnet at Geneva is now completely designed; several full-scale models of individual magnet units were made in order to arrive at a satisfactory solution of the many difficult problems. At the time when the report was written the magnet had not been ordered; but it was expected that tenders would be invited early in 1956. The 50-MeV. injector accelerator is already being manufactured, to a design similar to that of the proton linear accelerator under construction for Harwell. Design of the building and foundations for the proton synchrotron is a major problem. The large magnet ring has to be maintained in a circle and on a plane to within an accuracy of a few tenths of a millimetre, since particle instability is easily induced by misalignment errors when alternating gradient focusing is used. Little was known about such small earth movements over long periods, and prolonged tests were made with an experimental section of ring building, together with much accurate survey work. A method has been adopted whereby a heavy concrete ring is supported by eighty concrete pillars embedded in the rock which lies some distance below the surface. Construction of the ring building is now well advanced, and excavations for the laboratories and experimental hall have been made. The ring building will be mounded over with earth for radiation shielding, and heavy adjustable concrete walls, with beam channels, will be used for separating the experimental hall from the accelerator.

Synchrocyclotron. Most of the design of the 600-MeV. synchrocyclotron had been completed under the interim organization, with Prof. Bakker leading the design team. The magnet, with a pole diameter of 5 m. and containing 2,500 tons of steel, is under construction and was due for completion in August this year. The radio-frequency accelerating system is the most difficult problem in such a large synchrocyclotron. The system adopted is similar electrically to that evolved in Berkeley, California, for the conversion of the 184-in. synchrocyclotron there. The system at Geneva, however, is quite new mechanically, and the tuning-fork type of variable condenser is machined from a solid block of aluminium alloy. This system is also under construction, as are most of the auxiliary pieces of equipment for the accelerator. The heavy fixed shielding-walls have been built, and progress is being made rapidly on the remainder of the building work. Some of the staff of the Synchrocyclotron Division have been working in other laboratories, notably in the Universities of Liverpool and of Upsala, to gain experience of nuclear research with synchrocyclotrons in time for the commissioning of the machine at Geneva.

Other activities. The Scientific and Technical Services Division has been concerned with setting up electronics and mechanical workshops, instrumentation for nuclear research with the accelerators, and library and information services. A limited programme of cosmic-ray research has been started, to help the instrumentation activities to get under way. Design work on buildings had been pursued actively long before the final Organization was set up, and building work was started in 1954. At the end of 1955, 115,000 m.^{3} of earth had been excavated, and 11,000 m.^{3} of reinforced concrete had been set. The Organization has set up its own administrative machinery with its own staff and salary structure, terms of appointment, etc. The total number of staff employed at the end of 1955 was 286, of whom 108 were working on the proton synchrotron, thirty-two on the synchrocyclotron, forty-four on scientific and technical services, six on site and buildings, thirteen on theory, and fifty-nine on administration. These numbers will increase as the work develops. Detailed figures are given for expenditure during 1955, the total being about 18·8 million Swiss francs, or just over £1·5 million. The total expenditure for the first seven-year period is now estimated to be 197 million Swiss francs, plus an allowance of 10 per cent for contingencies.

The report, which is excellently written and produced, shows that the European Organization for Nuclear Research has made very good progress during its short existence so far. It is very encouraging that a co-operative project of such complexity, involving many countries, can be developed so effectively and smoothly. The value of the Organization to science generally, and to scientific progress in the member nations in particular, should more than repay all the effort and expense.

T. G. PICKAVANCE

COMMONWEALTH OBSERVATORY, CANBERRA

REPORT FOR 1955

THE Commonwealth Astronomer's report for 1955 on the Commonwealth Observatory, Canberra*, contains nine sections, the first of which, that dealing with time service and positional astronomy, includes an account of transit observations with the 3¼-in. reversible transit circle, which gave 171 determinations of clock error on 170 nights. Other matters referred to are: time signals, which were sent out four times each day, the average correction for the transmitted signal being 29 m.sec.; clock comparisons, maintained as in previous years, reports of which are forwarded to the Bureau International de l'Heure as a contribution to the determination of variations in the Earth's rotation; propagation of radio signals; and lastly, declination of *FK*3 stars. As the Munich observers completed their series of measures of declinations of southern stars with the Munich vertical circle, the instrument has been returned to its native city.

Section 2 of the report covers astrophysical investigations and is divided into various parts, the first of which is concerned with fundamental photometry; Dr. S. C. B. Gascoigne, assisted in the later stages by Dr. W. Heintz, completed the work of comparing the light from a calibrated standard lamp and that from twelve bright stars. This work is further reported under the heading of variable stars, in which Dr. Gascoigne continued the photoelectric observations

* Commonwealth Observatory, Canberra. Report of the Commonwealth Astronomer for the Year 1955. Pp. 5. (Canberra: Government Printer, 1956.)

of brighter galactic cepheids in two colours; the results are in course of preparation for publication, and curves for fourteen are already available. Dr. O. J. Eggen carried out photoelectric observations of short-period variables and discovered variations in four of these. Under the heading of spectroscopy, it is reported that the three-prism spectrograph at the Cassegrain focus of the Reynolds 30-in. reflector has been used for photographing more than five hundred spectra for radial velocity and about a hundred and eighty plates have been measured. This programme includes, *inter alia*, a study of the Scorpio–Centaurus cluster and some southern stars from the *N*30 Catalogue. In work on nebulæ and clusters, the theoretical studies are reported of the former Commonwealth Astronomer, Dr. R. v. d. R. Woolley, assisted by Mrs. D. A. Robertson, on the equilibrium conditions in globular clusters. Mr. A. W. Rodgers investigated obscuration in the Coal Sack region, and red and blue photographs of seven selected representative regions each approximately one square degree in area were obtained; the iris diaphragm photometer was used for measuring about two thousand stars. Under the heading of stellar atmospheres, reference is made to the work of Dr. A. Przybylski in the theoretical investigations on stellar atmospheres, on which he prepared two papers for publication.

In Section 3, dealing with buildings, grounds and equipment, the installation is announced of three major telescopes on which preliminary tests have been carried out: the 74-in. reflector, the 50-in. reflector which was previously the Great Melbourne telescope, and the 26-in. Yale–Columbia refractor. The first of these was officially opened by the Governor-General of Australia on November 8, 1955, and preliminary tests indicated a certain amount of astigmatism which, Hartmann tests at the prime focus suggest, is related to the method of supporting the primary mirror. The 50-in. reflector, set up as a Gregorian for a few nights for photoelectric observations, has proved satisfactory for this purpose. A plant for aluminizing the mirrors of both reflectors was in the course of delivery. The refractor has been installed, and extensive modifications by the Stromlo workshop have been carried out to such an extent that it has been possible to make preliminary tests. Among other matters referred to may be mentioned the Hilger recording microphotometer which is already in operation, and a spectrograph for use at the Newtonian focus of the 74-in. reflector, received from Carl Zeiss, of Jena.

In Section 4, in which workshop activities are reported, reference is made to the main work on the two reflectors and the 26-in. refractor, all of which have required attention from the electrical, mechanical and optical sections of the workshop. Essential maintenance was performed on telescopes, and mirrors of the 30-in. and 20-in. instruments were aluminized. A Muller-type double-image micrometer has been nearly completed.

The ionospheric prediction service (Section 5) has continued under Dr. W. Baker, and regular publication and exchange of ionospheric data have been continued. Routine measures of ionospheric characteristics were carried out at Canberra, Townsville, Brisbane and Hobart and in Macquarie Island. Dr. G. R. Ellis, working at Hobart, completed the investigations of the $\bar{Z}$ propagation hole in the ionosphere, and in association with Dr. G. Reber observations were made of low-frequency radio emission in the previously unexplored region below 9 Mc./s. Mr. F. E. Cook has continued the forecasting of ionospheric disturbances and has recommenced the observation of sunspots. Special ionospheric reports published include: "An Improved Method of Making High Frequency Radio Propagation Predictions", by J. Turner (Ionospheric Prediction Service *R*5); and "Forecasting of Geomagnetic Disturbances", by F. E. Cook (*R*6). Other sections of the report deal with publications, visiting astronomers and staff.

WEST AFRICAN MAIZE RUST RESEARCH UNIT

IN 1949 a rust disease, hitherto unrecorded in Africa, appeared on maize in Sierra Leone. Within three years the disease, which is caused by *Puccinia polysora*, had spread right across the continent and had appeared on islands more than a thousand miles from the east coast. The West African Maize Rust Research Unit, Ibadan, was instituted late in 1952, and the first annual report (1953) of this Unit gives an account of its first year's work. The general background to the problem is given in a foreword by Mr. D. Rhind, the sponsor of the scheme. The Unit is small, being staffed by two scientists, Dr. W. R. Stanton (geneticist) and Mr. R. H. Cammack (mycologist), who have the assistance of a locally recruited technical staff. The main centres of the work are Nigeria and the Gold Coast. The volume of data here accumulated pays tribute to the foresight of the authorities in establishing the scheme, as well as to the energetic activities of those undertaking the work. The three articles from the scientific staff of the unit are backed by a detailed body of information in the form of appendixes.

The plan of the work falls into two sections; first, observations on the course and causes of the epidemic; secondly, the breeding of resistant varieties of maize. The observations on the disease and the associated factors are thorough, and are well tabulated for ease in examination. The record forms an impressive catalogue of the facts that have been considered. The initial spread of the disease, with details of date first recorded in different countries, and with notes on severity and distribution within these countries, is well documented, forming a clear example of the severity with which a new disease may attack and spread. This disease is likely to become a classic to future generations of students of plant pathology. However, purely academic interest is not for long allowed to remain: the economic effects of the disease as quoted appear quite serious. Even before the Research Unit was instituted interim palliative measures, suggested by field observations, were applied, and had somewhat improved the situation. The value of the field observations presented in the report is increased due to the use of a highly standardized, quantitative field assessment method for determining the intensity of rust on a plant or plot, with a minimum of subjectivity. An early observation from plot experiments revealed that intensity of rust was variable with the site of the plot in the territory; this variation in intensity has now been correlated with rainfall and humidity factors. Some further interesting associations are found between time of planting and intensity of rust, time of onset of rust, rate of spread of rust, and yield of the plant. Reduced host vigour later in the season, and increase

in potential inoculum of the pathogen, are probably effective in the increased susceptibility of late planted maize. However, fast correlation of disease intensity with specific predisposing factors has not yet been made. Experiments on the effects of host vigour on susceptibility are promised. Such experiments may prove of wide importance, since soils in the maize-growing areas of West Africa, in common with those of other parts of the region, are poor in many of the properties regarded as desirable for the growth of plants. A comparative table of the major differences between *P. polysora* and the more common rust fungus which attacks maize, *P. sorghi*, is presented. This information should help to prevent the confusion between the disease caused by the two species which has apparently been possible in the past. It is shown that the two species differ in the physiology of their urediospores in respect of qualities relevant to infection in this part of the world. The greater virulence of *P. polysora* may be attributable in part to this factor.

The major part of the future work of the Unit would appear to be directed towards the breeding of resistant varieties of maize. So far only the uredial and telial states of the fungus are known: should the rust be truly hemicyclic then there is a high probability of the breeding programme being successful. One appendix to the report gives a list of more than three hundred seed acquisitions originating from most of the world's maize-growing areas. These have been tested under local conditions for resistance to the rust and for yield, and lines from New World sources show a generally high level of resistance. A score of lines promising in several characters, including resistance to other local diseases, have been selected for further work. The report emphasizes that the breeding project aims at a broader end than rust-resistance, the ultimate object of the Unit being to improve on the maize varieties that are currently grown in the region. With this aim in view a comprehensive discussion of the factors affecting maize yields in West Africa is given; in addition to the expected climatic, edaphic and husbandry factors, this discussion includes attention to peculiar local problems such as "elephant and monkey damage". A solution to some of the agronomic and cultural problems discussed here will be invaluable to the future development of the region as a whole.

Although this rust fungus appeared with great suddenness, and found local conditions and host plants favourable for its attack and spread, yet one feels from this report that the problem of the disease is well in hand.

DAVID PARK

ELECTRON SPIN RESONANCE IN MYOGLOBIN AND HÆMOGLOBIN

Orientation of the Hæm Group in Myoglobin and its Relation to the Polypeptide Chain Direction

IN experiments on two crystal forms of myoglobin, Bennett and Ingram[1] have found that the orientation of the hæm groups (one per molecule in myoglobin) relative to the crystal axes can be determined with considerable accuracy by measurements of electron spin resonance. The methods which they used are similar to those described in the following communication on hæmoglobin. They have now extended their investigations to include three further forms of myoglobin crystal (Bennett, Gibson and Ingram, data to be published), and in this paper we shall show how the results can be correlated on one hand with optical measurements of dichroic ratio, and on the other with indications of the predominant polypeptide chain directions derived from Patterson syntheses computed from X-ray diffraction data.

The hæm group contains a planar system of conjugated double bonds. Accordingly, one would expect it to act as a weak absorber of light when the electric vector of the incident (polarized) ray is normal to the plane of the group, and strongly when it lies in the plane. If it were known exactly how the absorption characteristics of a single hæm group varied with direction, then the three absorption coefficients of any myoglobin crystal could be calculated from the orientation of the hæm groups found by electron spin resonance. In the absence of precise data, one must make simplifying assumptions: the results to be quoted here indicate that in the met-form of the protein, it is a fair approximation to treat the hæm group as a two-dimensional circularly symmetrical absorber. It follows that if the direction cosines of the normal to the hæm group are l, m and n (relative to the crystal axes), and if, for example, the crystal is viewed in a direction parallel to c^*, the dichroic ratio is $(1-m^2)/(1-l^2)$ (this result is true for both monoclinic and orthorhombic crystals, the orthogonal axes of reference being taken as a, b and c^* in the former case). Table 1 gives the predicted and observed dichroic ratios for five different crystal forms of myoglobin; in all of them the agreement is satisfactory (except in type *D*, where the magnetic results are less accurate than the rest, and where the arrangement is such that the calculated dichroic ratio is very sensitive to

Table 1

Type	Species	Space group	Direction cosines of hæm group normals l	m	n	Dichroic ratio	Calc.	obs.	Direction cosines of rod directions l	m	n	Angle between rod direction and hæm normal	hæm plane
A	Sperm whale	$P2_1$	0·89	0·36	0·25	(∥c*)	4·2	4·0	0·44	0·34	0·78	40°, 59–65°	50°
						(∥a)	1·15	1·15					
B	"	$P2_12_12_1$	0·07	0·95	0·29	(∥c)	0·09	0·08–0·14	0	0·41	0·91	50°, 83°	40°
C	Seal	*A*2	0·69	0·20	0·69	(∥c)	1·8	1·8					
D	Blue whale	$P2_12_12_1$	0·7	0	0·7	(∥c)	0·7–1·3	1·4	0·57	0·46	0·68	43°, 83–89°	47°
F	Finback whale	$P2_12_12$	0·57	0·50	0·66	(∥c)	1·1	1·2	0	0	1	49°	41°

the exact orientation assumed). With crystals of derivatives of myoglobin other than met-myoglobin the agreement is much less good; thus the dichroic ratio of imidazole–myoglobin crystals is always less, and that of reduced crystals is always considerably greater, than the values quoted (Kendrew, J. C., and Parrish, R. G., unpublished results). Presumably in these derivatives the absorption characteristics of the hæm group must be more complicated than those postulated above.

We turn now to the question of polypeptide chain direction. Patterson syntheses of a number of crystal forms of myoglobin have been shown to contain rod-like regions of high vector density 10 A. apart[2]. These rods are most clearly visible in a three-dimensional Patterson synthesis of type *F* crystals (Bluhm, M. M., and Kendrew, J. C., unpublished results), in which the orientation of the molecules is particularly favourable, the rod direction being one of the crystal axes. In two-dimensional projections (usually all that are available) the rods are often obscured by other features of the vector structure, and may appear crossed at various angles to one another. However, it is sometimes possible to deduce unique orientations for the rods in (vector) space which are consistent with the features of all three principal projections. It has been postulated that these rods are the vector equivalents of a set of roughly parallel polypeptide chains forming a prominent feature of the molecule. In Table 1 we have listed the direction cosines of the rods deduced in this manner, together with those of the normals to the hæm groups, for all the crystal forms (except type *C*, where the interpretation of the Patterson projections is doubtful). We have calculated the angle between hæm normal and rod direction, with the results shown in the penultimate column. In general, alternative results are obtained, since we do not know which hæm group is associated with which set of rods (the unit cell may contain two or four of each, depending on the symmetry of the crystal). It will be seen that a value of 40–50° is consistent with the results for all the forms (the rod directions cannot be determined within 10°). The complement of this angle is the angle between the plane of the hæm group and the rod direction: the favoured solutions are listed in the last column.

The good agreement between the results for these four crystalline forms suggests that the angle between rods and hæm group is a characteristic feature of the myoglobin molecule even as derived from different species of animal. They suggest also that the rods in the Patterson projections are the vector equivalents of some feature of the molecules which has definite physical reality. If it be accepted that this feature is most probably a set of more or less parallel polypeptide chains, one is led to the interesting conclusion that in myoglobin these chains are oriented at an angle of 40–50° to the plane of the hæm group. Finally, the results for a given form are sufficient to determine uniquely the orientation of the molecules in the unit cell, and are thus a powerful aid in establishing the packing of the molecules in the different forms, a matter which will be enlarged upon in a subsequent publication.

D. J. E. Ingram

University of Southampton.

J. C. Kendrew

Medical Research Council Unit for the Study of the Molecular Structure of Biological Systems,
Cavendish Laboratory, Cambridge.
Aug. 17.

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[2] Kendrew, J. C., "Progr. in Biophysics and Biophysical Chem.", **4**, 244 (1954). Kendrew, J. C., and Pauling, P. J., *Proc. Roy. Soc.*, A (in the press). Kendrew, J. C., and Parrish, R. G., *Proc. Roy. Soc.*, A (in the press).

Orientation of the Four Hæm Groups in Hæmoglobin

The relation between the four hæm groups in hæmoglobin has been a subject of interest and speculation for a considerable time. The initial electron resonance measurements on single crystals of acid-met and fluoride hæmoglobin and myoglobin derivatives[1,2] indicated that the spectra are particularly favourable for accurate determination of orientation, since there is a large variation of g value from 6·0 to 2·0 as the applied magnetic field is rotated from a direction in the hæm plane to its normal axis. This variation forms the basis of the present analysis. All that is necessary, in principle, is to discover which crystallographic directions give the minimum g value of 2·0, and these are then known to be the directions of the normals to the hæm plane. In practice, the magnetic field is rotated around a convenient crystallographic plane and the orientation of the hæm normals found from the variation of g value with azimuth, the g value at any angle θ between the plane and the hæm normal being given[2] by $g^2 = 4(1 + 8 \sin^2 \theta)$. In an orthogonal system, it is therefore possible to determine the orientation of the axes from the results in a single plane; but for crystals of lower symmetry measurements in more than one plane may be necessary.

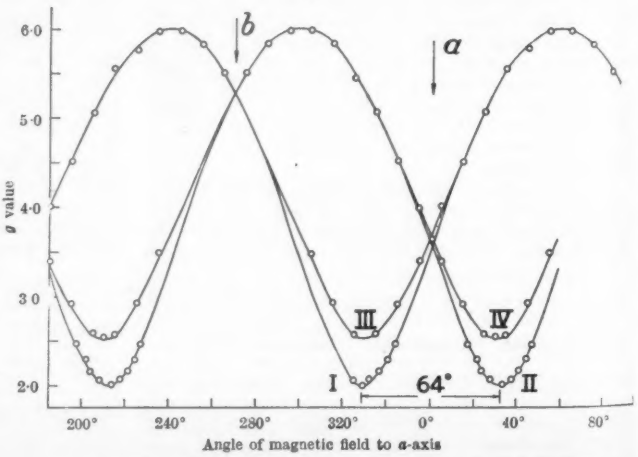

Fig. 1. Variation of g values with the direction of the magnetic field in the (001) plane of horse methæmoglobin

The measurements were made at a frequency of 36,000 Mc./sec. and at liquid-hydrogen temperatures, as for the myoglobin crystals[3], and standard methods of detection and display were employed[3]. Horse methæmoglobin crystals were chosen since they present a particularly favourable case. They are monoclinic and belong to the space group $C2$, with only two molecules in the unit cell[4]. The orientation of the two molecules is the same, each being placed on an axis of dyad symmetry. We should thus expect the four hæm groups belonging to each molecule to be arranged in two pairs symmetrically related by a dyad axis. The angular variation of g value obtained with a crystal mounted with the (001) plane horizontal (rotation about c^*) is shown in Fig. 1. All four curves have the same maximum g value of 6·0, since any arbitrary plane will always pass through the plane of the hæm group. Near the high g values the curves coalesce to form two pairs; but they separate near the low g values, showing that different hæm groups are inclined at different angles to the (001) plane. Two of the curves (I and II) are seen to reach the minimum value of 2·0, and hence two hæm normals are immediately located as lying in the (001) plane and at $\pm$ 32° to the a axis, which corresponds to the [110] and [1$\bar{1}$0] directions. The other two curves (III and IV) each have a minimum g value of 2·55 $\pm$ 0·10, corresponding to $\theta = 16 \pm 3°$. Their hæm normals must therefore enclose an angle of about 16° with the (001) plane, projecting on to it at an angle of 32° to the a-axis. These results are illustrated in a stereogram (Fig. 2).

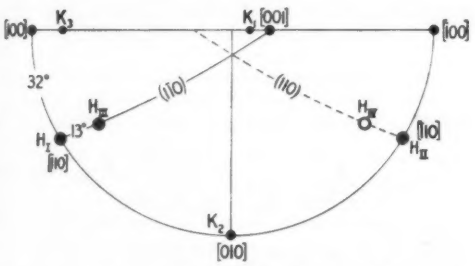

Fig. 2. Stereographic projection showing the poles of the normals to the hæm groups (H) relative to the monoclinic crystal axes. K_1, K_2 and K_3 refer to the principal directions of optical absorption

Another crystal was then mounted on the (110) face. In this case it was found that two of the curves had g values which remained close to 6·0, indicating that their hæm normals enclose a large angle with (110); these would correspond to the normals I and III in Fig. 2. The other two curves, corresponding to the normals II and IV in Fig. 2, both fall to the minimum of $g = 2·0$, showing that these two hæm normals lie in the (110) plane. However, the angle between the two minima is 13 $\pm$ 1°, which is more accurate than the angle of 16° deduced from the g value of curve IV in the (001) plane. The angles between the minima II and IV and the [001] and [1$\bar{1}$0] directions were then determined from the orientation of the crystal edges on the (110) face. One of the minima was found to coincide with [1$\bar{1}$0] as expected, and the other to enclose an angle of 13° with [1$\bar{1}$0] in the obtuse angle β. Other crystals were mounted to rotate about the a- and b-axes, with results confirming the above determinations. The

Table 1. Angles between Hæm Normals and Crystallographic Axes

	a	b	c^*	c
Hæm normals I and II	$\pm$ 32°	$\pm$ 58°	90°	108°
Hæm normals III and IV	$\pm$ 36°	$\pm$ 57°	77°	95°

orientations of the four hæm normals with respect to the crystallographic axes are therefore as shown in Table 1.

Fig. 3 is a perspective drawing in which the members of the two pairs are shown separately and in relation to the external shape of the hæmoglobin molecule[5].

The present measurements place no restrictions on the actual location of the hæm groups along the four normals, nor on their position in space, except that these must conform to the dyad symmetry of the crystal. Many different arrangements are thus compatible with our results. Three alternative kinds are illustrated in Fig. 4. In (*a*) and (*b*), the hæm groups are placed near the points of contact between neighbouring molecules in the (001) plane, whereas in (*c*) they are put next to the SH groups as suggested by Riggs[6].

In the preceding communication, Ingram and Kendrew show that in a variety of different forms of

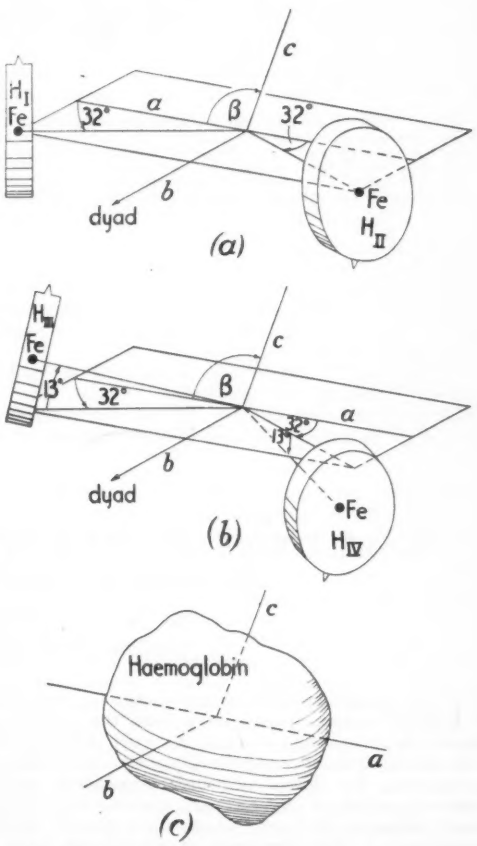

Fig. 3. Perspective drawing of the orientation of the hæm groups with respect to the crystal axes and the hæmoglobin molecule. (*a*) and (*b*) show the two pairs of hæm groups related by the dyad axis; (*c*) shows the external shape of the molecule, as determined by Bragg and Perutz (ref. 5), drawn on a much smaller scale than the hæm groups

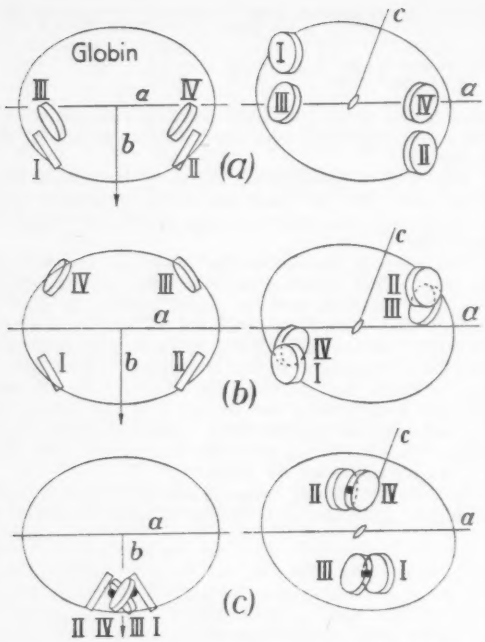

Fig. 4. Three of the many possible arrangements of the four hæm groups in the hæmoglobin molecule, represented diagrammatically as a spheroid. In each pair of drawings the left-hand one shows the molecule in projection normal to the dyad axis, and the right-hand one shows the same arrangement seen along the dyad axis. The small black points in (*c*) represent the positions of the SH-groups deduced from X-ray analysis

myoglobin the planes of the hæm groups enclose an angle of 40–50° with the polypeptide chain direction deduced from X-ray analysis. In hæmoglobin this angle is somewhat smaller (32° and 36°), so that there is no exact correspondence between the results obtained from the two proteins.

Ingram and Kendrew also show that the polarization dichroism of myoglobin crystals can be predicted from the results of electron spin resonance, by using the assumption that the hæm groups act as ideal two-dimensional absorbers. This calculation is useful both for the intrinsic interest of being able to predict the optical properties of a crystal and also as an independent check on the results—a check which is very sensitive, because the calculated dichroic ratios change by a large amount for a small change in the angles of the hæm normals. Horse methæmoglobin exhibits polarization dichroism of the negative uniaxial kind with dichroic ratios of $K_1/K_3 = K_2/K_3 = 2{\cdot}6$, and with K_3, the direction of least absorption, enclosing an angle of 10° with [100] in the obtuse angle β (Fig. 2)[7]. The results of electron spin resonance should thus allow one to predict both the angular orientation of K_1 and K_2 in the (010) plane and the dichroic ratios. Fig. 2 shows that K_3 lies roughly at the centre of the area marked out by the four hæm normals, which is the expected position; calculation shows that it actually lies within 3° of the predicted angle. The calculated dichroic ratios come to $K_1/K_3 = 3{\cdot}5$ and $K_2/K_3 = 2{\cdot}6$, which is probably as good agreement with the observation as can be expected in view of the simplicity of our assumptions.

It will be interesting to see if electron spin resonance can be obtained from reduced hæmoglobin, which has a different crystal structure and a dichroic ratio[7] of 4·5.

We should like to thank Dr. H. M. Dintzis and Mrs. T. M. Haughton for a supply of very large hæmoglobin crystals.

D. J. E. Ingram
J. F. Gibson
University of Southampton.
M. F. Perutz
Medical Research Council Unit for the Study of the Molecular Structure of Biological Systems,
Cavendish Laboratory,
University of Cambridge.

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POSSIBLE ROLE OF GROWTH INHIBITORS IN THE DORMANCY OF SEED OF *XANTHIUM* AND LETTUCE

By Dr. P. F. WAREING and H. A. FODA
Department of Botany, University of Manchester

THE dormancy phenomena shown by the seeds of *Xanthium* species have been the subject of many investigations during the past fifty years[1]. The fruits of *Xanthium pennsylvanicum* each contain two seeds, the 'lower' of which germinates readily after a period of dry storage, whereas the 'upper' seed remains dormant when sown under similar conditions. The dormancy of the 'upper' seed is considered to be due to the relative impermeability of the testa to oxygen, and is generally quoted as the classical example of dormancy due to this cause. Recent experiments by us, however, suggest that the dormancy of *Xanthium* seeds also involves certain germination inhibitors present in the embryo, as well as oxygen effects.

The leaves, fruit-coats and other parts of the plants of *X. pennsylvanicum* have been shown to contain a highly active growth-inhibitor, referred to as 'xanthinin'[2]. Preliminary experiments by us showed that although very little 'xanthinin' appears to be present in the seeds, the latter contain other inhibitors not present in other parts of the plant. These inhibitors from the seeds could not be extracted by solvents such as diethyl ether or absolute ethanol,

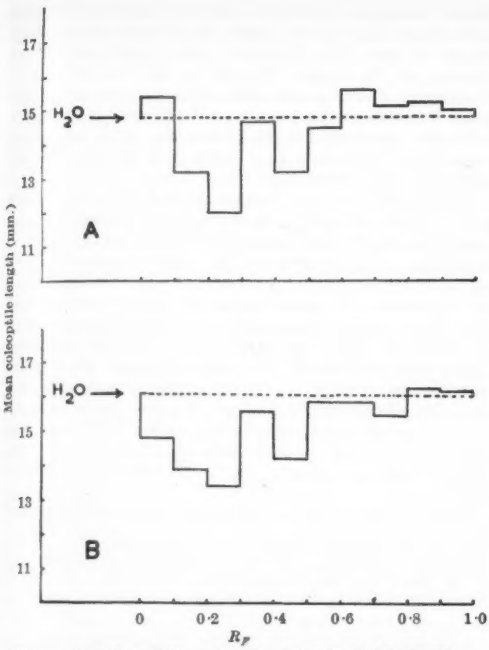

Fig. 1. Growth activity of aqueous extracts of (*A*) *Xanthium* seed and (*B*) lettuce seed, after separation by paper chromatography, using 75 per cent isopropanol + 25 per cent aqueous ammonia (0·88 S.G. × 1/100) as running solvent. Abscissæ: R_F value. Ordinates: growth of 10 mm. wheat coleoptile sections. The dotted horizontal line indicates the growth of control sections in water. Ordinates below this line indicate growth inhibition

but were readily extracted by water or 50 per cent aqueous ethanol. The concentrated extracts were chromatographed on paper, using 75 per cent isopropanol + 25 per cent aqueous ammonia (specific gravity, 0·88 × 1/100) as a solvent. The chromatograms were assayed for growth-activity using primarily the 'straight-growth' method with coleoptiles of oats or wheat. Two highly active growth-inhibiting zones (referred to as *A* and *B*) were found to occur at R_F 0·1–0·3 and 0·4–0·5, respectively (Fig. 1). The high activity of these inhibitors is shown by the fact that an extract of the inhibitor *A* from 1 gm. of seed in 10 ml. of water brings about 58 per cent reduction of growth of the coleoptiles. The *A* inhibitory zone shows a bright green fluorescence, while the second zone *B* gives a blue fluorescence, so that the position of the zones can be determined visually as well as by growth-activity. The *A* and *B* zones were also found to be strongly inhibitory to the growth of cress roots, the germination of lettuce seeds, and the growth of the radicles of *Xanthium*. Most of the growth-inhibiting activity present in the seeds is contained in the embryo itself, and is present in both the cotyledons and the radicle. The inhibitors were found to appear during the later stages of development of the embryo, and to disappear rapidly during germination.

The presence of highly active inhibitory fractions in the embryo raises the question as to whether they may play a part in the dormancy of the seeds. It seemed possible that the presence of the testa may promote dormancy by preventing leaching of the inhibitors from the embryo, apart from any effect it may have on gaseous exchange. This hypothesis is supported by the observation that whereas the inhibitors are rapidly leached out of the isolated embryos by water, very little inhibitory activity can be extracted from the *intact* seeds by leaching. A number of further experiments were carried out to test the 'inhibitor hypothesis'. For this purpose it was found that freshly harvested seeds provided very favourable material. Immediately after harvesting, both upper and lower intact seeds are dormant and cannot be induced to germinate so long as the testas are intact.

An experiment was carried out with two series of freshly harvested seeds, which were soaked in a large volume of water for 48 hr. The testas were removed from one series of seeds before the period of soaking, while the other series was soaked with the testas present. After the period of soaking, the testas were removed also from the second series of seeds. Both series were then sown in Petri dishes under conditions which would preclude any further leaching during the germination test. It was found that the embryos from which the testas were removed prior to soaking germinated readily, whereas those which retained the testas during soaking did not germinate. When the 'leaching' experiment was repeated and the embryos maintained in an atmosphere of pure oxygen after sowing, both series of embryos germinated. This latter result establishes two important points, namely: (1) failure of the unleached embryos to germinate in air is evidently not due to inadequate water-uptake during the period of soaking of the intact seed; (2) when precautions are taken to avoid any leaching after sowing, unleached embryos require increased oxygen tensions for germination even in the absence of the testa. Thus, the requirement of the intact, upper seeds for increased oxygen tensions cannot be ascribed wholly to impermeability of the testa to oxygen. On the other hand, the effect of soaking the isolated embryos suggests that dormancy of the freshly harvested and after-ripened seeds may be removed by the leaching out of water-soluble inhibitory substances, which are prevented from being leached out in the presence of the testa. Determination of the activity levels of the inhibitors in leached and unleached embryos confirmed that leaching does, indeed, result in a marked decrease in the inhibitor-content. Dormancy may thus be overcome either by leaching or by increasing the oxygen supplies to the tissues.

Further experiments were carried out to determine whether the effects of increased oxygen could be related to changes in inhibitor content. It was found that when isolated embryos were maintained in pure nitrogen they remained dormant and the fluorescent inhibitory material in the radicles remained present. When, however, the embryos were maintained in an atmosphere containing sufficient oxygen for germination, then the fluorescent material in the radicles became greatly reduced within a period of 30 hr., before any appreciable radicle elongation could be detected. This observation suggested that the inhibitors may undergo enzymically controlled breakdown in the presence of oxygen. Cell-free extracts were prepared from the radicles of germinating seedlings by extracting the macerated tissue with water, followed by precipitation with acetone. On re-dissolving the precipitate in water, it was shown that the extract was capable of bringing about the rapid breakdown, *in vitro*, of the fluorescent inhibitory material, when mixed with the latter. This breakdown *in vitro* can only occur in the presence of

atmospheric oxygen. The activity of the cell-free extract was destroyed by boiling. Cell-free extracts from the leaves of older plants of *Xanthium* were also shown to bring about breakdown of the seed inhibitors. These observations suggest that an oxidase system is present in the tissues, which is capable of bringing about breakdown of the inhibitor in the presence of oxygen. It seems possible, therefore, that the stimulation of germination by increased oxygen tensions is due to a specific effect upon the breakdown of the inhibitors, rather than to an increase in the rate of respiration and general metabolism.

Experiments were carried out to determine whether any difference in inhibitor content could be detected (1) between freshly harvested (dormant) and after-ripened (non-dormant) lower seeds, and (2) between upper (dormant) and lower (non-dormant) *after-ripened* seeds; but no appreciable difference in inhibitor content could be detected as between these various types of seed. It would appear, therefore, that the changes in the depth of dormancy occurring during after-ripening in dry-storage are not primarily ascribable to differences in inhibitor-content, but may involve activation of the enzyme-system which brings about the breakdown of the inhibitors.

There is a close parallelism between the dormancy phenomena occurring in *Xanthium* seed and in those of birch[2] and certain varieties of lettuce. We have found, moreover, that when lettuce seed is extracted and separated by the same chromatographic technique as used for *Xanthium* seed, inhibitory zones appear at the same R_F values as the *A* and *B* inhibitors of *Xanthium* seed (Fig. 1), and show the same fluorescence properties as the latter. By analogy with the phenomena in *Xanthium*, it would thus seem that inhibitors may also play a part in the dormancy of lettuce seed.

It has not hitherto been reported that *Xanthium* seed is light-sensitive; but we have recently found that dormant, intact upper seeds can be induced to germinate if exposed to 18-hr. daily photoperiods of an intensity of 5,000 lux at 25° C. Under 10-hr. photoperiods the germination is much reduced, and the seeds remain completely dormant if maintained in darkness. The day-length effect is enhanced if the seeds are subjected to temperatures alternating between 25° and 18° C. How far this is a true photoperiodic phenomenon requires further investigation. The demonstration that germination of *Xanthium* seed is promoted by light indicates a further resemblance with dormancy effects in birch and lettuce seed.

These studies will be published in detail elsewhere.

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GLASSES BASED ON THE OXIDES OF MOLYBDENUM, TUNGSTEN AND URANIUM

By Dr. P. L. BAYNTON, H. RAWSON and J. E. STANWORTH
Research Laboratory, British Thomson-Houston Co., Ltd., Rugby

In previous publications from this Laboratory, attention has been directed to glasses of unusual composition based on the oxides of tellurium and vanadium[1-4]. This article describes the development of further unusual glasses based on the oxides of molybdenum, tungsten and uranium.

The first stage of the work was to investigate the glass-forming behaviour of melts in a large number of binary systems. A very small quantity (10–20 mgm.) of each mixture was melted in a V-shaped kink in a resistance-heated platinum alloy wire. When the mixture was completely molten it was quenched by switching off the heating current. The melt was observed using a stereoscopic microscope with a magnification of 25. The method will be described in more detail elsewhere.

Binary mixtures of MoO_3 with the following oxides were investigated: Li_2O, Na_2O, K_2O, CaO, SrO, BaO, PbO, ZnO, MnO, Al_2O_3, Bi_2O_3, P_2O_5 and V_2O_5. Glass formation was observed in the systems Li_2O–MoO_3, Na_2O–MoO_3, K_2O–MoO_3 and BaO–MoO_3, the glass-forming compositions containing about 91, 87, 63 and 80 per cent of MoO_3, respectively. These glasses, which were transparent and coloured amber, devitrified very easily and could not be made on a scale larger than 20 mgm. The composition range of glass formation in each system was very narrow—about 5 per cent. Glass formation was also observed in the MoO_3–P_2O_5 system with all mixtures containing more than 11 per cent P_2O_5. These glasses, which were coloured black, did not devitrify easily. Stable glasses can also be made in the system MoO_3–TeO_2, and the properties of these glasses have already been described[3].

Very similar results were obtained in the binary systems containing WO_3. Binary systems of WO_3

Table 1. Compositions of Molybdate and Tungstate Glasses melted on the Scale of 20 gm.

Glass No.	Composition—Wt. per cent						Colour	Thermal expansion coefficient (10^{-7}/°C.)
	WO_3	MoO_3	P_2O_5	BaO	K_2O	Na_2O		
*W*1	75·6	—	20·0	—	—	4·4	Black	74
*W*2	66·7	—	27·4	—	—	5·9	Black	92
*M*1	—	76·5	19·3	—	—	4·2	Black	136
*BM*1	—	57·0	22·8	15·3	—	4·9	Black	145
*PM*3	—	69·6	15·4	—	11·7	3·3	Black	204
*PW*1	71·1	—	11·8	—	14·7	2·4	Amber	180

with the following oxides were investigated: Li_2O, Na_2O, K_2O, Tl_2O, Cu_2O, MgO, CaO, SrO, BaO_1 PbO, ZnO, CdO, MnO, NiO, B_2O_3, Fe_2O_3, As_2O_3, Bi_2O_3, SiO_2, TiO_2, GeO_2, P_2O_5, V_2O_5, Nb_2O_5, MoO_3. Colourless glasses which devitrified very readily were obtained in the systems Na_2O–WO_3 and K_2O–WO_3, the glass-forming compositions containing about 80 and 82 per cent of WO_3, respectively. Much more stable glasses were obtained in the system WO_3–P_2O_5 with all mixtures containing more than 11 per cent of P_2O_5. These glasses, like the MoO_3–P_2O_5 glasses, were black. A few WO_3–P_2O_5 glasses have been described previously by Rothermel, Sun and Silverman[5]. Stable WO_3–TeO_2 glasses can also be made[3].

Binary mixtures of UO_3 with the following oxides were investigated: Li_2O, Na_2O, K_2O, Cs_2O, CuO, MgO, CaO, SrO, BaO, ZnO, CdO, PbO, B_2O_3, Al_2O_3, SiO_2, GeO_2, TeO_2, P_2O_5, V_2O_5, As_2O_3, Sb_2O_3, Bi_2O_3, Nb_2O_5, Ta_2O_5, Fe_2O_3, NiO, MnO, WO_3 and MoO_3. It was found that the glass-forming behaviour of UO_3 is different from that of MoO_3 and WO_3, in that it more readily forms glasses with acidic oxides. Glasses were formed in the UO_3–V_2O_5 system with UO_3 contents between 20 and 60 per cent. These glasses, which were black, devitrified fairly readily; the most stable glass contained 30 per cent UO_3. Black glasses were also obtained in the UO_3–MoO_3 system with UO_3 contents between 40 and 55 per cent. These glasses devitrified readily and there was considerable volatilization at the melting temperature. Some indication of glass formation was observed in the UO_3–WO_3 system at the composition 50 per cent UO_3, 50 per cent WO_3. Finally, glass formation was observed in the UO_3–TeO_2 system with mixtures containing 10–20 per cent of UO_3; these glasses were yellow. Further small-scale experiments

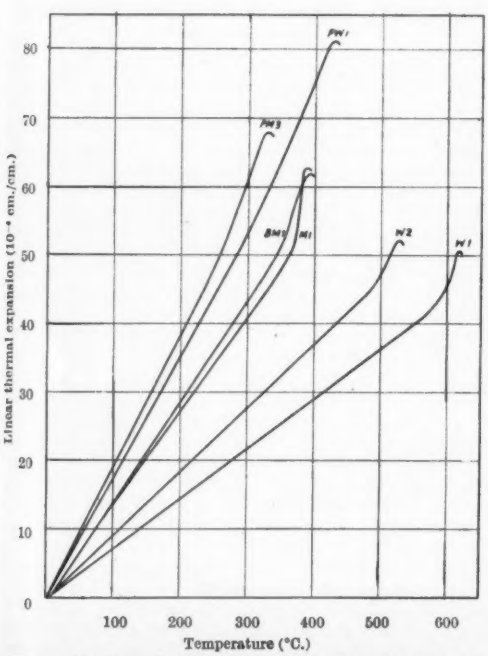

Fig. 1. The thermal expansion curves of some molybdate and tungstate glasses

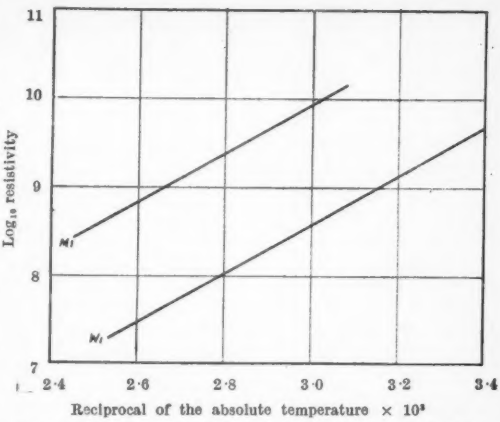

Fig. 2. The change in resistivity with temperature for a molybdate and a tungstate glass

indicated that high percentages of UO_3 could be introduced into sodium borate, sodium silicate and sodium phosphate glasses. UO_3 could be most easily introduced into the Na_2O–P_2O_5 system, and glasses could be made containing up to 40 per cent UO_3.

The K_2O–WO_3, K_2O–MoO_3, BaO–MoO_3 and UO_3–V_2O_5 melts which formed glasses when melted on a scale of 20 mgm. devitrified on cooling when melted on a scale of 1–2 gm. Experiments were carried out to determine whether the glasses could be stabilized by the addition of a third component. By far the most promising results were obtained by additions of P_2O_5, and it was found, for example, that with an addition of 10 per cent P_2O_5 to BaO–MoO_3 melts it was possible to make glasses on the scale of 20 gm. The addition of 5 per cent of P_2O_5 or TeO_2 was sufficient to stabilize melts in the V_2O_5–UO_3 system and glasses were obtained on the scale of 20 gm. Although glasses could not be made even on a 20-mgm. scale in the system WO_3–UO_3, the addition of 5 per cent P_2O_5 gave stable glasses which could be melted on a scale of several grams. An additional effect of adding P_2O_5 was to widen the composition range of glass formation.

The compositions of six tungstate and molybdate glasses are given in Table 1 together with their thermal expansion properties. Thermal expansion curves, and curves showing the change in electrical resistivity with temperature are shown in Figs. 1 and 2. The glasses were melted on the scale of about 20 gm. in silica crucibles at 1,000° C. The black colour and relatively low resistivity coupled with the absence of d.c. polarization effects indicate that the glasses of low alkali contents containing WO_3 and MoO_3 are semiconductors. This is presumably due to the presence of some of the molybdenum and tungsten in lower valency states. No attempt has yet been made, however, to establish the valency state of the molybdenum, tungsten and uranium in these glasses.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Absolute Configuration and Optical Rotation of Folded (α) Polypeptides

Since Pauling and Corey[1] proposed the α-helix for the structure of some folded polypeptides, evidence for the essential correctness of this structure has accumulated; but agreement between the observed X-ray diffraction pattern of oriented fibres and that calculated from the model has not been obtained. As Brown and Trotter[2] have recently shown, with α poly-L-alanine ($(CO.CH.CH_3.NH)_n$), where the scattering centre of the side-chain is fixed with respect to the helix, the agreement along the layer lines is very poor. In this case, the X-ray reflexions can be indexed on a unit cell through which only one chain passes, and it was assumed that both the sense of the helix (right- or left-handed) and the direction of the peptide sequence were identical for all chains. The fit was so poor that it could not be concluded with certainty whether the helices were right- or left-handed.

Since the α-helix conforms accurately to the conditions for minimum energy and also has dimensions which are almost exactly those required to fit the unit cell of poly-L-alanine, it seems likely that the atomic parameters of this helix must be very nearly correct. We have accordingly examined more general arrangements of eighteen-residue, five-turn helices (fibre repeat 27 A.), using the reflecting optical diffraction spectrometer which was described recently[3]. The fibre repeat in poly-L-alanine is longer than this[2], but the effect of the longer repeat on the optical transform is not appreciable. Like-handed hexagonal arrangements of helices which have near six-fold screw axes pack with the observed inter-chain distance whether all chains have the same direction of peptide sequence or not; the necessary condition is that the β-carbon atoms of the methyl side-chain groups should be in identical crystallographic positions. A random arrangement of the direction of the peptide sequence of the individual chains (which is very probable in the absence of strong polarizing forces) will produce the diffraction pattern of a primitive unit cell, though there is, in the strict sense, no unit cell. This arrangement of right-handed helices (corresponding to βC_1^4) gives diffraction patterns in much better agreement with the observed X-ray pattern than does a left-handed one. The refinement of co-ordinates is not yet complete, but enough has been done to show that satisfactory agreement may be expected with quite minor changes in the co-ordinates originally given by Pauling and Corey[5]. It is most unlikely that any appreciable proportion of left-handed helices contributes to the crystallite reflexions. It is possible, however, that left-handed helices contribute to the observed layer-line streaks; but in this case the proportion would be small. We believe, therefore, that in poly-L-alanine the helices are mainly right-handed, and presumably α-helices of other L-amino-acid polymers will also be right-handed.

The specific optical rotation of an α-helix of poly-glycine (using a very simplified model) has recently been calculated by Fitts and Kirkwood[6]; for right-handed helices this is found to be +132°, in an aqueous solution with index of refraction 1·35. Poly-L-(or poly-D)-alanine is not soluble in non-polar solvents, and since in polar solvents the chains may be random coils (at least at low polymer concentrations) a direct measurement of the specific rotation of an α-helix of poly-L-alanine cannot well be made. However, a *meso* polymer containing a small proportion of one enantiomorph is slightly soluble in chloroform. From measurements on such material, the specific rotation of poly-L-alanine is about +50°, which is considerably less than the figure given by Fitts and Kirkwood for a right-handed helix without active side-groups. Unless their estimate is grossly in error, it would appear that the contribution of the side-chain opposes the form optical rotation of the helix. This would account for the generally low value of the specific rotation of polypeptides in conditions which favour the α-helix form. Fitts and Kirkwood[7] have recently, from similar considerations of optical rotation, also concluded that α-polypeptides form right-handed helices.

A. Elliott
B. R. Malcolm
Research Laboratory, Courtaulds, Ltd.,
Maidenhead, Berks.
Aug. 3.

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An Improvement of the Hydrazine Method for Determination of C-Terminal Amino-acids

Hitherto, investigators using the hydrazine method of Akabori and co-workers[1] found it necessary to treat the peptides or protein with anhydrous hydrazine at not less than 100° for about 10 hr. in order to break all peptide bonds[2-4]. This severe treatment causes complete decomposition of cysteine, cystine and poor yields of arginine, aspartic acid and glutamic acid, with the result that they cannot be determined satisfactorily as C-terminal amino-acids. It is now shown that by the addition of an acid catalyst it is possible to decompose peptides under much milder conditions so that all the common amino-acids can be recovered in fair yield.

About 10 mgm. peptide or amino-acid and 26 mgm. $N_2H_4H_2SO_4$ were dried for about 3 hr. at room temperature under vacuum conditions (about 10^{-4} mm. mercury), 0·2 ml. 100 per cent N_2H_4 distilled in, the tube sealed, heated at 60° for 16 hr. and the excess hydrazine evaporated off over concentrated sulphuric acid in a vacuum desiccator. The residue was dissolved in about 1 ml. dilute hydrochloric acid, shaken with 0·4 ml. benzaldehyde for 2 hr., the aqueous solution separated by centrifugation and dinitrophenylated by Levy's method at 40° in *M*/2 carbonate buffer[5,6]. The aqueous solution (about 8 ml.) was extracted with ether (4 × 5 ml.), acidified with hydrochloric acid and extracted five times with 5 ml. ethyl acetate. The dinitrophenyl-amino-acids and unchanged peptides were separated by one-dimensional paper chromatography using the toluene,

phosphate and *t*-amyl alcohol solvents[7]. (With lysozyme it was necessary to remove the dinitrophenol by vacuum sublimation at 40° prior to one- and two-dimensional chromatography). The spots were cut out, eluted with 1 per cent sodium bicarbonate and the optical density measured at 360 mμ (385 mμ for dinitrophenyl-proline) with a Unicam spectrophotometer. These values were converted to percentage yields (accuracy ± 10 per cent) using the results from dinitrophenylation, extraction and chromatography of each amino-acid or peptide separately.

From Fig. 2 it is clear that the hydrazinolysis of DL-leucylglycine is virtually complete after 16 hr. at 60° in hydrazine containing 1·0 *M* hydrazine sulphate but requires 80° for 16 hr. in the absence of catalyst. Since the yields of glycine are approximately the same by both methods (see Fig. 1) the milder acid-catalysed reaction is of no advantage in this particular case. However, it is to be preferred in general because of the greatly increased stability of some of the amino-acids at 60°. From Table 1 it is clear that all the reactive amino-acids, except tryptophan and histidine, are recovered in much better yields, particularly arginine, aspartic acid, cysteine, cystine and glutamic acid. A number of peptides are included to show the application of the method in this field. A 45 per cent yield of leucine was obtained from lysozyme (molecular weight 14,900), and further work on proteins, which is now in progress, will be reported later.

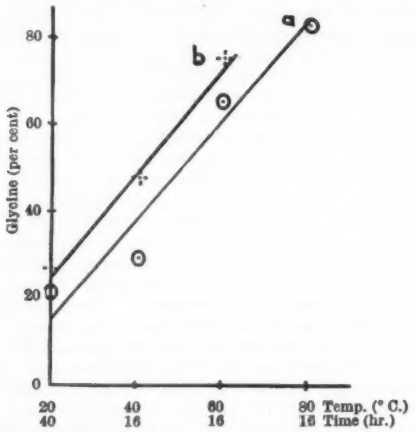

Fig. 1. Yield of glycine on hydrazinolysis of DL-leucylglycine: *a*, no catalyst; *b*, 1·0 *M* $N_2H_4H_2SO_4$

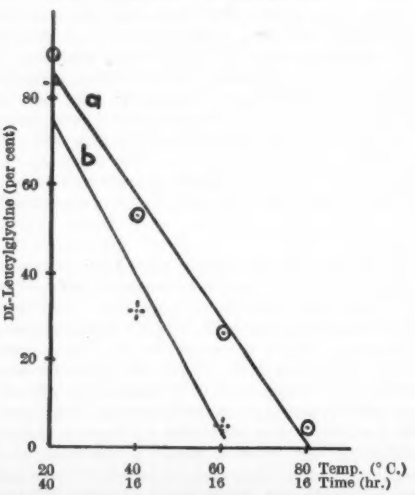

Fig. 2. Yield of unchanged DL-leucylglycine on hydrazinolysis of DL-leucylglycine: *a*, no catalyst; *b*, 1·0 *M* $N_2H_4H_2SO_4$

Table 1. YIELD OF C-TERMINAL AMINO-ACID OR AMINO-ACID ON HYDRAZINOLYSIS OF PEPTIDES AND AMINO-ACIDS

Material	C-Terminal amino-acid (%)	
	60°—16 hr. 1·0 *M* $N_2H_4H_2SO_4$ in N_2H_4[a]	100°—8 hr. N_2H_4, Niu and Fraenkel-Conrat (ref. 3)
L-Arginine hydrochloric acid	60[b]	25[b]
L-Aspartic acid	99	19
DL-Cysteine hydrochloric acid	86[c]	0
L-Cystine	78	0
L-Glutamic acid	76	16
DL-Histidine	53	43
L-Lysine hydrochloric acid	90	47
DL-Methionine { met.	66	0
DL-Methionine { met. sulphoxide	35	56
DL-Proline	97	52
DL-Serine	96	39
DL-Threonine	105	52
DL-Tryptophan	46	39
DL-Alanylglycine	92	39
DL-Glycylleucine	69	
DL-Glycylphenylalanine	98	
L-Glycyltryptophan	20[d]	
L-Glycyltyrosine	65	
DL-Leucylglycine	75	
Glutathione	91 gly	

a, Yield of unchanged peptide always < 5 per cent; *b*, L-arginine completely destroyed and determined as ornithine (ref. 3); *c*, DL-cysteine completely oxidized to cystine and determined as such; *d*, 56 per cent yield in absence of $N_2H_4H_2SO_4$, hence the breakdown of tryptophan must be catalysed by acid.

I wish to thank Dr. M. Lipson for his interest in this work, Miss Ruth M. Dedman for technical assistance and Dr. E. O. P. Thompson for helpful discussions and the supply of lysozyme.

J. H. BRADBURY

Wool Textile Research Laboratory,
Commonwealth Scientific and
Industrial Research Organization,
Geelong, Victoria.

May 30.

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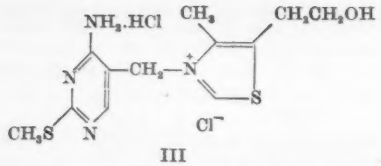
A New Antagonist of Thiamine

4-AMINO-5-hydroxymethyl-2-methylthiopyrimidine[1,2] (I) is an inhibitory antagonist of the pyrimidine moiety of vitamin B_1 (II)[3]. However, a thiamine-requiring mutant of *Escherichia coli* (strain *M*70–17) which can use II for growth will grow in the presence of I if the thiazole moiety of thiamine is also supplied. One possible explanation of this is that, under these conditions, the pyrimidine I is being converted to a functional thiamine-like compound. Consequently, it was decided to synthesize the thiamine analogue derived from I, which would differ from thiamine only in the nature of the 2-substituent, and



III

which, on the basis of a recently proposed mechanism of thiamine action[4], might be expected to have thiamine activity.

4-Methyl-5-(β-hydroxyethyl)-N-(4-amino-2-methyl-thiopyrimidyl-(5)-methyl)-thiazolium chloride hydrochloride (III) was synthesized by standard methods[5] from I, and its analysis was found to be satisfactory. Instead of replacing thiamine as a growth factor, III was found to be an inhibitory antagonist of thiamine in *E. coli*. The molar ratio of competition (inhibitor/thiamine) was of the order of 100 at concentrations which gave 50 per cent inhibition of growth. Thus, growth of strain *M*70–17 obtained with 0·0001 μgm./ml. of thiamine was inhibited 50 per cent by 0·01 μgm./ml. of III and 100 per cent by concentrations over 0·1 μgm./ml. An increase in the concentration of thiamine required a proportional increase in the concentration of III to give the same level of inhibition.

The corresponding 2-ethylthio compound has been tested on *Amoebae* and is inactive[6]. It would appear that enzyme systems have much more specific structural requirements than the chemical system studied by Breslow[4].

In view of recent work on the metabolic interaction of vitamins B_1 and B_6[7], it may be of interest that the pyrimidine I has also been found to be an antagonist of pyridoxine[3].

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T. L. V. Ulbricht

Department of Pharmacology,
Yale University School of Medicine,
New Haven, Connecticut.

J. S. Gots

Department of Microbiology,
University of Pennsylvania School of Medicine,
Philadelphia 4, Pennsylvania.

July 9.

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Factors favouring Restriction to 1,2 Glycols of Materials coloured by the Periodic Acid–Schiff Reaction

While periodate oxidation was reported first as a histological method for the demonstration of mucin[1], subsequent studies showed its utility for the colouring of glycogen[2] and other carbohydrates or carbohydrate-containing materials[3] in tissue sections. In its present histochemical use, periodate oxidation of tissue sections produces aldehyde presumably from certain specific linkages, chiefly 1,2 glycols and amino, alkyl-amino or ketone substituents of 1,2 glycols. The aldehydes produced by periodate oxidation are coloured with Schiff's reagent.

The initial confidence that only materials containing large numbers of 1,2 glycol linkages, presumably carbohydrates, were being coloured by Schiff's reagent after periodic acid (the PAS reaction[4]) was somewhat tempered by the fact that serine, threonine and 'hydroxylysine' would produce aldehyde after periodate oxidation[5] and quite possibly give a positive periodic acid–Schiff reaction. It was soon indicated that the susceptible linkages would not be available for oxidation in the polypeptide chain of the usual protein molecule and that only terminal serine, threonine and hydroxylysine would be expected to produce aldehyde on periodate oxidation[3]. Since the original publications on periodate oxidation in histochemistry, a number of relevant studies have appeared in the chemical literature without particular notice by histochemists. These are sufficiently important to be mentioned in this communication. The whole subject of periodate oxidation in histochemistry has been reviewed *in extenso* in a separate publication.

The originally described solution of periodic acid for histochemistry, and that which is most commonly used, is 0·5 per cent in distilled water. This has a molarity of 0·022 and a *p*H of 2·1 [6].

α-Glycols, hydroxyaldehydes, hydroxyketones and diketones are oxidized fastest in a slightly acid medium (*p*H 3–5)[7], while α-amino alcohol, amino aldehydes, amino ketones and diamines require a neutral or slightly alkaline medium (*p*H 7–8) for optimal oxidation-rate[8]. The hydroxyaldehydes, hydroxyketones, diketones, amino aldehydes and amino ketones would be expected to produce a coloration with Schiff's reagent without prior periodate oxidation. The diamines and α-amino alcohols do not react rapidly at the *p*H present in 0·5 per cent aqueous periodic acid. Dyer[9] points out that "simple and unhindered α-glycol and α-amino alcohol groupings will be nearly completely oxidized in 5–10 min. at their *p*H of optimum reaction if a moderate excess of periodate is present". The conditions of histochemical periodate oxidation, with a section on a glass slide immersed in a container of the oxidant solution, guarantees an excess of oxidant. The oxidation time originally used was two minutes, now it is five minutes. Dyer indicates further that periods of time longer than 5–10 min. are required for the oxidation of α-hydroxyaldehydes, α-hydroxyketones, α-ketoaldehydes, α-diketones and the corresponding amino derivatives. So long ago as 1941, Van Slyke, Hiller and MacFayden[10] had reported that excess of free periodic acid was associated with slow and incomplete reaction with hydroxylysine and serine.

These data from organic chemistry concerning the influence of time, excess of reagent, *p*H and molarity on periodate oxidation reinforce the belief that materials colouring with Schiff's reagent, presumably aldehydes, which are produced in tissue sections by 5 min. oxidation with 0·5 per cent periodic acid, in all probability consist of, or contain, 1,2 glycol groups and are presumably carbohydrates. Observations to the contrary, that materials of known carbohydrate nature do not give a positive periodic acid–Schiff reaction, and notably that of Jeanloz[11] with cellobiose, can be explained, as pointed out by McManus and Hoch-Ligeti[12], by technical difficulties such as the

aldehyde-blockade produced by the use of bisulphite after periodate oxidation.

J. F. A. McManus

Department of Pathology,
University of Alabama Medical Center,
Birmingham 3, Alabama.
July 12.

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Effect of Carbon Dioxide Inhalation on the Blood-Brain Barrier

The trypan blue test has been used for studies of damage to the blood-brain barrier caused, for example, by carbon monoxide[1]; but so far as can be seen from the literature no investigation has been carried out on the effect of carbon dioxide on the barrier. Histopathological changes after prolonged exposure to carbon dioxide have been reported by Stephens[2]. They consisted mainly of swelling, chromatolysis and vacuolation of nerve cells.

The present experiments were performed on rabbits which were exposed to various concentrations (10, 15, 20 and 30 per cent) of carbon dioxide in oxygen in a gas chamber. The exposure times varied from 2 to 60 min. Ten minutes before the exposure a trypan blue solution was injected intravenously. Ten minutes after the exposure the animals were killed and their vessels were washed out with normal saline followed by a 20 per cent formalin solution for fixation. On serial frozen sections the whole brains were examined for blue stainings and hæmorrhages.

30 per cent carbon dioxide for 2 min. scarcely caused any obvious changes; but already after 3 min. exposure more consistent changes were seen. After 4, 5 and 10 min. exposure the changes were more pronounced, consisting of marked multiple stainings as well as multiple hæmorrhages. After 15 min. or more the changes often were maximal. Some of these brains were almost totally blue, and there were rich hæmorrhages in the brain substance and the meninges.

In animals exposed to the lower concentrations of carbon dioxide the changes were proportionally less pronounced and occurred only after a somewhat longer exposure. However, still with 10 per cent carbon dioxide and 15 min. exposure clear changes were seen.

The damage to the walls of the blood vessels obviously was reversible within a short time, which was shown by the fact that when trypan blue was injected a few minutes after the gas exposure, the stainings were only slight and the hæmorrhages were unstained.

It may be questioned whether the cause of the barrier damage was a vigorous dilatation of thin-walled vessels or maybe a direct toxic effect on the endothelial membranes. The results indicate that hypercapnia is a factor that should not be disregarded as a cause of cerebral damage, for example, in asphyxia, where the component of anoxia sometimes seems to have been over-emphasized.

A detailed account of this work is to be published elsewhere.

Carl-Johan Clemedson
Hans Hartelius
Gunnar Holmberg

Medical Department,
Research Institute of National Defence,
Sundbyberg,
and
King Gustaf V's Research Institute,
Stockholm, Sweden.
July 18.

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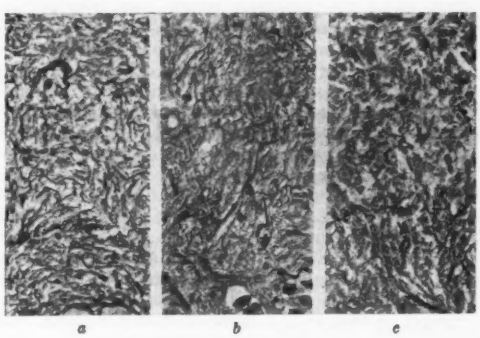
Nature of Reticulin

For a long time there has been confusion in the use of the name 'reticulin' to describe the argyrophilic fibrous structures present as basement membrane in the parenchymatous organs and also to describe fibres which are histologically similar but which are present in developing connective tissue. Recently, however, a number of workers[1-3] have shown that the basement membrane type of reticulin is a complex composed of collagen, carbohydrate and lipid which are released only after acid hydrolysis. Windrum *et al.*[3] have questioned the assumption that the two types of reticulin are identical. We now report evidence which suggests that they are indeed different structures.

In the early stages of development of a granuloma produced by subcutaneous injection of carrageenin[4], the fibres present are largely of the reticulin type. Such tissue has been subjected to a differential extraction procedure[4] and examined histologically after each extraction. The histological examination showed that: (*a*) after extraction with 0·2 *M* sodium



a *b* *c*

Fig. 1. Carrageenin granuloma after six days.
a, Normal control showing abundant silver staining reticulin fibres; *b*, after neutral salt extraction the fibres lose their argyrophilia and stain red with Van Gieson; *c*, extraction with citrate buffer after neutral salt gives almost complete removal of fibres.
All stained under identical conditions by silver impregnation/Van Gieson. (× *c.* 120)

chloride, *p*H 7·4, the fibres failed to stain with silver but took up the Van Gieson stain for normal collagen fibres; (*b*) following this with extraction with citrate buffer *p*H 3·6 removed the fibres almost completely (Fig. 1). The process extracts citrate-soluble collagen from the tissue[4], and this has been shown to contain little or no carbohydrate[5] and no lipid (unpublished data). Hence this type of reticulin is different from the reticulin of the parenchymatous organs. Extraction with 0·2 *M* sodium chloride removes neutral salt-soluble collagen[6], and it may be that the silver staining is due to the presence of a layer of this collagen type which is not yet incorporated firmly into the collagen fibre structure, although it has been shown recently that coating mature collagen fibres with a number of substances induces them to stain with silver[7].

This investigation will be reported in detail elsewhere.

D. S. Jackson
G. Williams

Pathological Laboratory,
Rheumatism Research Centre,
University, Manchester.
Aug. 15.

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An Isotope-Derivative Method for the Detection and Estimation of Œstrogens

About ten years ago Keston and co-workers developed an isotope dilution method for the estimation of amino-acids[1]. This method, by which the amino-group of amino-acids is labelled with radioactive 'pipsyl chloride' (*p*-iodophenylsulphonyl chloride, labelled with iodine-131), was not found applicable for other types of compounds until recently. Last year, however, this method was also used for the detection and estimation of histamine[2], pyrimidines[3] and 17-hydroxycorticosterone[4]. In the last method the labelling agent was 'pipsan' (*p*-iodophenylsulphonylic acid anhydride).

In this laboratory we are interested in the detection and estimation of œstrogens in the blood of dairy cattle and other animals. Not being satisfied with the usual fluorimetric and colorimetric methods, we adapted the pipsyl chloride method to our investigation.

From our experiments it appears that the phenolic group in ring *A* reacts easily with pipsyl chloride in a 0·75 per cent solution of borax in 75 per cent acetone. The reaction is almost complete in 15 min. at room temperature if about 10 μgm. of œstrogen are esterified with 2 mgm. of pipsyl chloride in 0·4 ml. of 75 per cent acetone solution. Whether the hydroxyl groups at C_{17} (œstradiol and œstriol) and C_{16} (œstriol) are partially esterified under the given conditions has not yet been elucidated. The excess of reagent can be hydrolysed by adding a 2 per cent aqueous borax solution and heating at 50° C. for 30 min. Partition between benzene and water leaves the hydrolysed reagent in the aqueous phase, whereas the pipsyl derivatives and some both hydrolysed and non-hydrolysed pipsyl chloride are left in the benzene layer. Pipsyl chloride and the pipsyl derivatives of œstrone, œstradiol-17β and œstriol can be separated from each other by a paper chromatographic method, using Schleicher and Schüll 2043[a] paper, previously dipped in a 10 per cent solution of paraffin oil in ether. An ascending technique is applied with mixtures of carbon tetrachloride/paraffin oil (7 : 2) and cyclohexane/paraffin oil (3 : 1) as the mobile phases. Complete separation is achieved after a 15 hours run (Fig. 1). The latter solvent has the disadvantage that the œstriol derivative remains on the start.

Fig. 1. Autoradiographs of the paper chromatographic separation of pipsyl chloride (1) and the pipsyl derivatives of œstrone (2), œstradiol-17β (3) and œstriol (4). Solvents: *A*, carbon tetrachloride–paraffin oil 7 : 2; *B*, cyclohexane–paraffin oil 3 : 1

So far amounts up to 0·3 μgm. œstrogen could be detected. We are continuing our experiments with more active preparations of pipsyl chloride to increase the sensitivity of the method.

In preliminary experiments blood samples of both non-pregnant and pregnant cows were examined. Extracts were prepared according to the usual methods for œstrogen determination. Each time one litre of blood was worked up. In the extracts a number of compounds which react with pipsyl chloride was detected. Whether one or more of these compounds are identical with one of the three common œstrogens is under investigation. A method for the quantitative determination of œstrogens by means of the isotope indicator method, which makes use of an indicator labelled with pipsyl chloride-^{35}S [5], is also under development.

Results and details of the method will be published elsewhere.

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D. C. LEEGWATER

Laboratory of Veterinary Biochemistry,
State University of Utrecht,
Biltstraat 172, Utrecht.
July 5.

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Studies on the Biosynthesis of Neuraminic Acid

In recent years neuraminic acid[1] and several of its derivatives, such as sialic acid and lactaminic acid, have been shown to be constituents of mucoproteins, gangliosides and related naturally occurring substances. Although the chemical structure of neuraminic acid has not been established as yet, its elementary composition and some of its chemical properties are known. The existence of this substance as either the free carboxylic acid or its corresponding lactone form has been demonstrated[2], and it has been postulated that a hexosamine residue is present[3]. The biological function of neuraminic acid remains obscure, although recent evidence indicates that this compound is liberated from its parent polysaccharide by the action of influenza virus or virus-receptor-destroying enzymes[3,4].

Since the biosynthetic origin of neuraminic acid has not been studied, an investigation was carried out with four objectives in mind: (1) to investigate the biosynthetic relationship between neuraminic acid and glucose and its metabolic precursors; (2) to establish on biosynthetic grounds whether a hexosamine residue is actually present in neuraminic acid; (3) to throw light, if possible, on the origin of the carbon atoms not associated with the postulated hexosamine residue; and (4) to provide carbon-14-labelled neuraminic acid which could be used to establish its chemical structure.

In the experiments to be reported here, uniformly labelled D-glucose-^{14}C with a specific activity of $4{\cdot}53 \times 10^6$ counts/min. per mgm. of carbon was injected intraperitoneally into rats in two experiments. The total carbon-14 activity injected into each rat was 14,887,000 counts/min. (8·2 mgm. of glucose-^{14}C). In the first experiment, two rats, each weighing 250 gm. and fasted for 8 hr., were injected with glucose-^{14}C in three equal doses at 2-hr. intervals. Twelve hours after the last injection the animals were killed, skinned and their combined tissues converted to a dry powder after homogenizing with acetone in a Waring blendor. The second experiment was conducted similarly but with only one rat weighing 450 gm. and fasted for 25 hr. before being given glucose-^{14}C. The carbon-14 activity of samples plated out on planchets as infinitely thin layers was measured in a gas-flow counter. Neuraminic acid, glucosamine and galactosamine were isolated from the acetone powders.

A newly devised procedure, the details of which will be published elsewhere, was used for isolating neuraminic acid. In brief, this isolation procedure involves the following steps: (1) The powdered carcass was refluxed with 5 per cent hydrochloric acid-methanol (w/v) for 5 hr. (2) After removal of the excess hydrochloric acid from the supernatant, 0·2 *N* aqueous mercuric chloride was added and the resultant precipitate discarded. The filtrate was then neutralized with 'Amberlite *IR* 4*B*' (OH form). (3) The filtrate and aqueous washings obtained from this resin were combined and placed on a column (2·5 cm. × 70 cm.) of 'Dowex-50', 4 per cent cross-linked, 200–400 mesh. In the upper third portion of this column, 'Dowex-50' was present in the mercuric form, whereas the lower two-thirds of the column contained the cation exchanger in its hydrogen form. The column was washed with water until the effluent solution did not show a green colour upon addition of Bial's reagent. (4) The column was now eluted with 0·3 *N* hydrochloric acid, whereupon hexosamine and the neuraminic acid were obtained in two discrete fractions. The hexosamine fraction was eluted first, and from it glucosamine and galactosamine were isolated according to the method of Gardell[5]. (5) The effluent fraction containing neuraminic acid was concentrated to a small volume after removal of hydrochloric acid. The concentrate was placed on 'Dowex-50' (H form) in a column (2·5 cm. × 40 cm.) and neuraminic acid was eluted with 0·3 *N* hydrochloric acid with a yield of approximately 12 mgm. per 100 gm. wet tissue. Neuraminic acid was crystallized after removal of hydrochloric acid from a mixture of methanol, water and petroleum ether (boiling point 30°–60°) and recrystallized first from methanol-water and then from water.

Neuraminic acid intended for use as carrier substance was isolated by the same procedure from bovine submaxillary mucopolysaccharide. The elementary analysis of this material (C, 42·49; H, 7·02; N, 4·55 per cent) was in good agreement with that reported by Klenk and Lauenstein[1]. The chemical identity and homogeneity of the unlabelled carrier substance and the radioactive material isolated was established as follows: (1) The absorption coefficient of the coloured material resulting from Bial's reaction was compared with that of an authentic sample of neuraminic acid; we are indebted to Prof. E. Klenk for supplying us with a sample of methoxy neuraminic acid for comparison with our material. (2) Paper chromatography was carried out in one of the two systems: (*a*) *sec*-butanol/acetic acid/water (4 : 1 : 5), and (*b*) *n*-butanol/acetic acid/water (4 : 1 : 1). (3) Infra-red spectra were used for comparison with an authentic sample. (4) Radiochemical purity after repeated recrystallizations served as an index of purity in the case of the carbon-14-labelled material.

In all instances, neuraminic acid was isolated as its methoxy derivative. Glucosamine and galactosamine were isolated as the hydrochlorides. The carbon-14 activity of the isolated compounds is

Table 1. CARBON-14 ACTIVITY OF NEURAMINIC ACID, GLUCOSAMINE AND GALACTOSAMINE

	Activity (counts/min./mgm. carbon)	
	Experiment 1	Experiment 2
Neuraminic acid	1,170	980
Glucosamine	1,560	
Galactosamine	2,580	

expressed as counts/min. per mgm. of carbon (Table 1). In the case of neuraminic acid, the carbon-14 activity has been corrected to eliminate the isotope dilution due to the methoxy carbon atom. In the case of the hexosamines, the carbon-14 activity represents that of the free hexosamine.

The results appear to support the thesis that the carbon atoms of glucose contribute directly to the biosynthesis of neuraminic acid, but do not warrant any conclusions as to the mechanism of biosynthesis. Since the injected glucose-^{14}C was diluted by the rat's glucose pool, which has been reported to be 130 mgm. per 100 gm. of rat tissue[6], it can be estimated that the isotope concentration in neuraminic acid has undergone a dilution of less than one hundred-fold. The extent of this dilution is interpreted as being indicative of a direct contribution of glucose carbon atoms to the biosynthesis of neuraminic acid.

A comparison of the specific carbon-14 activity of neuraminic acid with that of glucosamine and galactosamine shows that the isotope concentration of glucosamine approaches that of neuraminic acid but is less than that of galactosamine by a factor of 1·7. Although the pool-sizes of some of the intermediates as well as the rates of turnover are unknown at present, it seems reasonable to postulate that glucosamine is not a likely precursor of neuraminic acid, but that galactosamine could conceivably function in such a capacity.

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Karl Lauenstein*
Kurt I. Altman

Department of Experimental Radiology,
University of Rochester School of Medicine
and Dentistry,
Rochester, New York.
May 29.

* Max Kade Fellow.

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Separation of Steroid Conjugates by Paper Electrophoresis

The application of the principle of electrophoretic separation on paper to steroids is limited by their relatively low polarity, so that they do not readily migrate under the influence of an electric current, and also by their sparing solubility in aqueous media. By converting the steroids into derivatives with polar groupings, some separation has been achieved (Voigt and Beckmann[1], 1953, using the hemisuccinates; McKinley[2], 1955, using the mono- and di-phenylhydrazone derivatives). Our early experiments, begun before the publication of these authors' results, were along similar lines, and with somewhat similar results. It did not seem likely, however, that electrophoretic separation would be so convenient a method as chromatography, which has been adapted by Lembart and Schneider[3] for the separation on paper of mixtures of pure steroid conjugates. The natural occurrence of more polar steroid derivatives, the sulphates and glucuronides in urine, suggested to us that these might undergo electrophoretic separation on paper. Although the individual steroids could not be resolved, the two groups of conjugates were sharply separated.

The apparatus used was a simple box type, accommodating the paper strips horizontally. Of several systems tried, a veronal buffer solution of ionic strength 0·1 and *p*H 8·6 containing 20 per cent ethanol was found to give the best results. Whatman No. 31 filter paper was used, and a potential difference of 240 volts and a current strength of 0·5 m.amp. per cm. of paper was applied for 16 hr. A mixture of dehydroisoandrosterone and its sulphate subjected to electrophoresis under these conditions showed that the steroid sulphate travelled 11 cm. towards the anode while the free steroid had moved slightly towards the cathode. An extract containing both the free and conjugated steroids was obtained from urine by half saturation with ammonium sulphate followed by extraction with an ether–alcohol mixture. An amount of extract containing approximately 200 micrograms of total steroid was used for separation. After drying, the paper strip was treated with Zimmermann reagent. Two violet bands were obtained, both on the anode side of the point of application, the glucuronide fraction varying from 5 to 7 cm., and the sulphate from 8 to 10 cm. from the initial line. In addition, a very small amount of free steroid was found at, and slightly to the cathode side of, the starting point. A number of bands due to other non-steroid urinary constituents were also present; for example, a brown band of urea was always seen at about 1 cm. on the cathode side.

In addition to experiments on mixtures of known steroids, further evidence suggesting the composition of the two fractions was given by showing that the glucuronide fraction was almost completely removed by previous treatment of the urine with glucuronidase before extraction, and by demonstrating the virtual absence of glucuronic acid in the sulphate fraction. The fractions can also be quantitatively estimated after elution from an unstained strip, and this has been carried out both for normal and pathological urines and for blood. Table 1 shows the results from a normal adult urine, as an example.

Table 1

	Amount applied	Free steroids	Sulphates	Glucuronides
17-ketosteroids	140 μgm.	3 μgm.	37 gm.	99 μgm.
17-OH corticosteroids	88 μgm.	2 μgm.	6 gm.	82 μgm.

Besides affording a simple means of estimating the proportions of steroid sulphates and glucuronides in urine and blood, for which, so far as we know, there is no direct method, the procedure can also be applied for purifying the fractions prior to hydrolysis and subsequent identification of the components, and also for preparative purposes. Work along these lines is actively proceeding, and fuller details of the method and its applications will be published elsewhere.

B. Levin
G. Davies

Department of Pathology,
Queen Elizabeth Hospital for Children,
Hackney Road, London, E.2.
July 21.

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Effect of Di*iso*propylphosphorofluoridate on the Acetylcholine Content of Flies

PREVIOUS studies[1,2] of the action of di*iso*propylphosphorofluoridate (DFP) on insects have been primarily concerned with the inhibition of cholinesterase, but nothing has been reported about its effect on the acetylcholine (ACh) content. We have therefore examined the effect of di*iso*propylphosphorofluoridate on acetylcholine-levels in the blowfly (*Calliphora erythrocephala*) and the housefly (*Musca domestica*).

Flies were immobilized by cooling at 0° C.; 10 μgm. di*iso*propylphosphorofluoridate in 1 μl. acetone was applied to the dorsal surface of the abdomen, and, when paralysed (about 3 min.), the flies were transferred in groups to open dishes. At intervals after treatment with di*iso*propylphosphorofluoridate a group was taken for acetylcholine determination, either on the whole flies, or on the heads, thoraces or abdomina. Acetylcholine was extracted by the method of Lewis and Smallman[3], and assayed on the eserinized rectus abdominis muscle of the frog. Corresponding estimations were made on control flies treated with 1 μl. acetone only. The results are shown in Fig. 1.

In the whole fly there is a slow increase in acetylcholine content after di*iso*propylphosphorofluoridate treatment; but the distribution of acetylcholine within the insect is markedly influenced. In the head the level of acetylcholine begins to fall after about ½ hr., and at 3½ hr. it is only about 25 per cent of the control value. In the thorax there is an increase in acetylcholine content; but most striking is the accumulation of acetylcholine in the abdomen, where the level rises from less than 0·0005 μgm./abdomen in the control to about 0·07 μgm./abdomen in the poisoned fly after 3½ hr.

In comparable experiments with the housefly we have shown a similar fall in the acetylcholine content of the head of the insect poisoned with di*iso*propylphosphorofluoridate. Winteringham and Harrison[4], working with houseflies injected with 2-^{14}C-acetate,

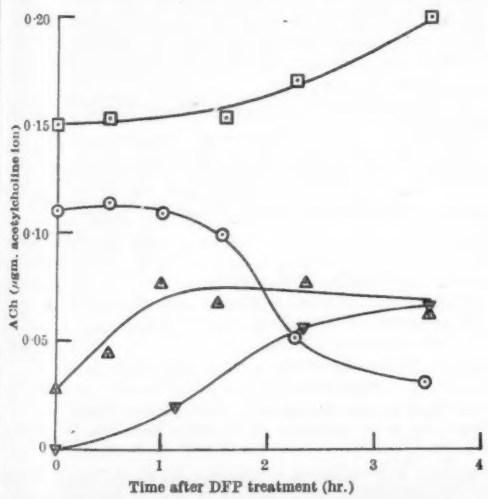

Fig. 1. Change in acetylcholine-levels in the blowfly after treatment with di*iso*propylphosphorofluoridate. (Levels in the untreated fly are plotted at zero time.) ⊡—⊡, Whole fly; ○—○, head; △—△, thorax; ▽—▽, abdomen

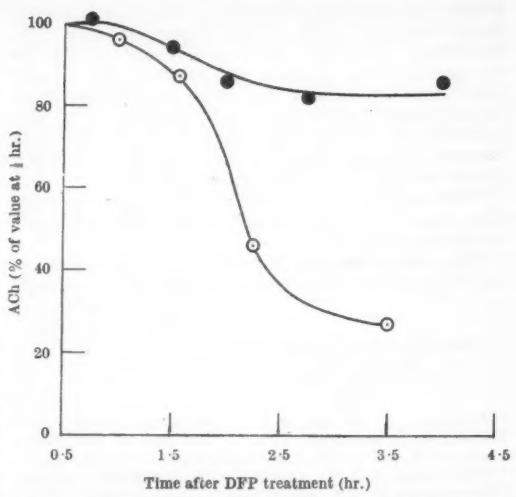

Fig. 2. Effect of decapitation on the fall in acetylcholine-level in the head of the blowfly treated with di*iso*propylphosphorofluoridate. ○—○, Head of intact fly; ●—●, head isolated ½ hr. after treatment with di*iso*propylphosphorofluoridate

reported that of the total soluble carbon-14 in the head the proportion present as acetylcholine was doubled ½ hr. after treatment with di*iso*propylphosphorofluoridate, but after 5 hr. had fallen to the control level; and it may therefore appear that our results are in contradiction to their findings. However, these workers have also shown[5] that the total soluble carbon-14 in the head (mainly in amino-acids) is decreased ½ hr. after treatment with di*iso*propylphosphorofluoridate, so that the increase in the proportion of carbon-14 present as acetylcholine does not represent a corresponding increase in the absolute amount of acetylcholine.

We have also measured the acetylcholine content of the head of the poisoned blowfly at intervals after decapitation. Flies were decapitated ½ hr. after treatment with di*iso*propylphosphorofluoridate in groups of fifteen. Heads from one group were extracted immediately after decapitation and those from the remaining groups at intervals up to 3½ hr. The change in acetylcholine content in these heads after decapitation is shown in Fig. 2 in comparison with that occurring in the head of the intact poisoned fly over a similar period (both sets of values expressed as percentages of the acetylcholine content ½ hr. after treatment with di*iso*propylphosphorofluoridate). It is clear that the fall in the level of acetylcholine in the head of the fly treated with di*iso*propylphosphorofluoridate is largely prevented when the head is isolated from the rest of the body.

Similar experiments with abdomina cut from flies ¾ hr. after treatment with di*iso*propylphosphorofluoridate showed that the acetylcholine-level in the isolated abdomen remained constant, whereas that in the abdomen of the intact poisoned fly continued to increase.

These results suggest that the changes in the amount of acetylcholine in the head and abdomen of the fly treated with di*iso*propylphosphorofluoridate are due mainly to redistribution of acetylcholine within the insect and not to destruction or synthesis *in situ*. Although it might be expected that such a redistribution would occur via the hæmolymph, no significant

amount of acetylcholine could be detected in hæmolymph from flies treated with di*iso*propylphosphorofluoridate. However, much of the acetylcholine in the abdomen was found in the contents of the hind-gut. Thus it may be that, in flies treated with di*iso*propylphosphorofluoridate, acetylcholine is in fact redistributed via the hæmolymph, but is removed from it and reconcentrated in the hind-gut, possibly by the action of the Malpighian tubules.

Fuller details of these and of other experiments on flies treated with di*iso*propylphosphorofluoridate will be reported elsewhere.

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S. E. Lewis
K. S. Fowler

Pest Infestation Laboratory,
Slough, Bucks.
June 15.

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Determination of Fat in Mutton Carcasses by Measurement of Specific Gravity

In albino rats[1], guinea pigs[2], swine[3] and cattle[4] a close relationship has been shown to exist between specific gravity and percentage fat in the eviscerated carcass. Likewise in living man[5] a relationship has been established between specific gravity and percentage fat in the body.

In the present work the relationship between specific gravity of the whole carcass and the percentage fat content of the half carcass and of certain joints has been determined on three groups of five six-year-old Romney pasture-fed ewes reared under typical New Zealand flat-country conditions. The first group of ewes was killed at the outset of the experiment. The second and third groups were killed twenty-eight days later. Animals in the second group were pasture-fed for 1 hr. and starved for 23 hr. per day for the duration of the experiment, while the animals in the third group were grazed on pasture throughout.

After chilling for approximately 18 hr. after slaughter, the specific gravity of the kidney-free carcasses was determined by weighing in air and then in water at a water temperature of 17°–20° C. The surface temperature of carcasses was 11°–12° C.

Following the determination of whole carcass specific gravity the carcasses were stored for a period in a freezing chamber. The frozen carcasses weighing 55·2–78·2 lb. were then divided down the middle of the back with a meat band saw and the right side sliced into pieces one-eighth to one-quarter of an inch in thickness, again using the band saw. These slices, consisting of bone, muscle, fat and other tissues, were then readily minced.

Obtaining a uniform mince of all the soft and hard tissues of the carcass has hitherto presented great difficulty. This has been effectively overcome by the technique just described which, so far as we are aware, has not previously been recorded in the literature. Slight modifications of this technique are also being investigated in this Department in studies of functional anatomy, parturition and whole-animal chemical determinations of meat animals.

The fat content in six samples per animal was determined by using a slight modification of the method of Barnicoat and Shorland[6]. The standard error of the mean of these six samples was ± 0·39 and the coefficient of variation was 2·5 per cent. Percentage fat from the 15 half-carcasses varied from 26·1 to 45·4, and specific gravity of the whole carcasses varied from 1·009 to 1·049.

The left side of each carcass was divided into leg and loin, described by Pálsson[7], as well as a ninth–tenth–eleventh rib cut. The bone, muscle and fat contents were determined by dissection following the method of Pálsson[7].

The linear regression equations of the dependent variables Y, Z, U and W on the independent variable specific gravity together with their standard errors of estimate and their correlation coefficients are as follows:

Where X is $\frac{1}{\text{specific gravity}}$; Y is per cent ether extract fat in half-carcass; Z is per cent dissectable fat of leg plus loin; U is per cent ether extract fat in 9–10–11 rib cut; W is per cent dissectable fat in 9–10–11 rib cut; then

$$Y = 100\left(\frac{5{\cdot}680}{\text{specific gravity}} - 5{\cdot}138\right);$$

$$S_{x.y} = 3{\cdot}196 \text{ per cent}; \qquad r_{xy} = 0{\cdot}877;$$

$$Z = 100\left(\frac{4{\cdot}965}{\text{specific gravity}} - 4{\cdot}512\right);$$

$$S_{x.z} = 3{\cdot}131 \text{ per cent}; \qquad r_{xz} = 0{\cdot}852;$$

$$U = 100\left(\frac{7{\cdot}386}{\text{specific gravity}} - 6{\cdot}695\right);$$

$$S_{x.u} = 4{\cdot}706 \text{ per cent}; \qquad r_{xu} = 0{\cdot}877;$$

$$W = 100\left(\frac{6{\cdot}479}{\text{specific gravity}} - 5{\cdot}810\right);$$

$$S_{x.w} = 4{\cdot}764 \text{ per cent}; \qquad r_{xw} = 0{\cdot}814.$$

These results show that the relationship between specific gravity of the whole carcass and the percentage fat content of the half-carcass and joints is high. Thus the specific gravity method of estimating percentage fat content reported for other species can be applied in the sheep.

A detailed report of this investigation will appear elsewhere.

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R. A. Barton
A. H. Kirton

Sheep Husbandry Department,
Massey Agricultural College,
University of New Zealand,
Palmerston North,
New Zealand.
May 28.

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Synthesis of Levan by Pseudomonads

THE property of forming levan from sucrose is rather common among *Bacillus* species[1] and is also found in *Streptococcus salivarius*[2] and *Aerobacter levanicum*[3,4]. Further, levan is produced by many phytopathogenic *Pseudomonas* and *Xanthomonas* species[5,6], and is said to be formed by *Pseudomonas betae-gelatae*[7], isolated from thawing sugar-beets. However, no mention has been made of levan-producing *Pseudomonas* species isolated from other than diseased or killed plant material.

In the course of an investigation on levan-synthesizing bacteria, colloidal solutions of levan in distilled water were regularly stored in the icebox at 2° C. Some of these solutions were found to have become infected by organisms, apparently capable of using levan as sole source of carbon. After isolation, however, the predominating organism proved also to be able to produce a polysaccharide on 4 per cent sucrose with 1½ per cent peptone agar. After cultivation at 25° C. for 2–3 days in liquid 4 per cent sucrose 1½ per cent peptone medium, the polysaccharide formed was precipitated by adding three parts of ethyl alcohol and identified as a levan according to the methods of Hestrin *et al.*[3]. Further examination showed the organism to be *Pseudomonas fluorescens*.

Since here a levan-synthesizing pseudomonad was found which did not originate from plant material, it seemed worth while to examine the possibility of a dependable enrichment culture for this organism. Sterile 1 per cent solutions in distilled water of levans of different origin were inoculated with garden soil, ditch water or tap water. After incubation for 2 days at 25° C. under aerobic conditions and subculturing once more in the same liquid medium, transfers were made on 4 per cent sucrose with 1½ per cent peptone agar. Several strains of the predominating, slime-producing organism were readily isolated, all of which have been proved to be levan-forming *Pseudomonas fluorescens* strains. Apparently, small amounts of impurities in the levan preparations and inoculation materials fulfil the mineral requirements of this organism. These simple growth conditions in the enrichment medium were found to be essential for its selectivity, since the mere addition of mineral salts caused a great variety of other organisms to come to the fore.

Furthermore, it has been found in this laboratory that *Pseudomonas aureofaciens* is a levan-forming bacterium, as already mentioned recently by Kluyver[8]. All strains examined possessed this property; they were isolated from mixtures of clay and kerosene (2 strains) and soil (1 strain).

On screening a number of *Pseudomonas* strains from the bacterial collection of our laboratory, four more strains, belonging to the species *Pseudomonas fluorescens* (3 of 8 strains) and *Pseudomonas chlororaphis* (1 strain), were found to be able to synthesize this polysaccharide. None originated from plant material.

No levan synthesis was found in about 80 strains of different *Pseudomonas* species, among which were: *Ps. putida*, *Ps. aeruginosa*, *Ps. fluorescens*, *Ps. aromatica* var. *quercito-pyrogallica*, *Ps. calco-acetica* and *Ps. punctata*.

Thus, in a total of three *Pseudomonas* species, levan-forming strains have been found, which did not originate from diseased or killed plant material. All these strains produce levan in considerable quantities; maximal production was shown by a strain of *Pseudomonas aureofaciens* which in one case produced 83 per cent of the theoretical yield on cultivation at 25° C. in 4 per cent sucrose with 1½ per cent peptone medium on a rotary shaker.

The greater part of the levan-synthesizing strains which have been identified as *Pseudomonas fluorescens* is able to use oxygen as well as nitrate as hydrogen acceptor. These nitrate-reducing strains appeared able to synthesize levan also in nitrate-containing sucrose media in total absence of air. Here, maximal production of levan was 49 per cent.

All the levan-producing *Pseudomonas* strains proved to have constitutive, endocellular levan-sucrases (= saccharose → levan-transfructosidase[9]); moreover, all these strains could be characterized on sucrose-containing agar media by colonies having a typical radial structure. In these respects, apparently all Gram-negative, levan-producing bacteria resemble each other closely since *Aerobacter levanicum* was found to show the same characteristics.

A. FUCHS

Laboratory for Microbiology,
Technological University,
Delft.
July 14.

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Occurrence of a Malic Enzyme free of Oxalacetic Decarboxylase in Silkworm Hæmolymph

HÆMOLYMPH of the larval silkworm (*Bombyx mori* L.) contains a triphosphopyridine nucleotide-linked 'malic' enzyme that has been purified by ammonium sulphate fractionation followed by adsorption and elution from calcium phosphate gel[1,2]. It was of interest to measure the oxalacetic decarboxylase activity of the 'malic' enzyme from silkworm, since those of pigeon liver[3,4] and wheat germ[5,6] exhibit a constant ratio (approximately 1·2 : 1) between oxalacetic decarboxylase and 'malic' enzyme activities throughout all stages of their purification. Recently, a diphosphopyridine nucleotide-linked 'malic' enzyme free of oxalacetic decarboxylase was purified from homogenates of *Ascaris lumbricoides*[7]. 'Malic' enzyme activity has been reported in crude homogenates of larvæ from the blowfly[8]. These extracts also decarboxylate oxalacetate; but it has not yet been established whether both reactions are catalysed by the same enzyme.

The test system used for the spectrophotometric assay of the 'malic' enzyme of silkworm blood contained the following components (in μmoles/2·2 ml.): *tris* (hydroxymethyl) aminomethane buffer *p*H 8·5, 40; magnesium sulphate, 10; *l*-malate, 10; triphosphopyridine nucleotide, 0·5; and enzyme. The assay was carried out in quartz cells ($d = 1·0$ cm.) at 21° C. in a Beckman *DU* spectrophotometer. The control cell contained all the components except

triphosphopyridine nucleotide. The activity of the 'malic' enzyme was calculated from the change in optical density at 340 mμ during the third minute of incubation; the unit being defined as that quantity which causes an increase in optical density of 0·01 unit/min.[9].

The manometric assay of oxalacetic decarboxylase was performed in the Warburg apparatus using flasks of approximately 5 ml. capacity; the test mixture contained the following (in μmoles/1·25 ml.): sodium acetate buffer, *p*H 4·5, 20; manganese chloride, 2·5; oxalacetate, 20; and enzyme. The oxalacetate, which had been brought to *p*H 4·5, was placed in the side arm and tipped after an equilibration period of 10 min. The gas phase was air and the incubations were carried out at 25° C. The control vessel contained enzyme inactivated by heating in a boiling-water bath for 3 min. and the gas evolved in this vessel was approximately the same as that produced in a vessel containing the complete incubation mixture without enzyme; thus, denatured silkworm-blood enzyme did not stimulate the non-enzymatic decarboxylation of oxalacetate. The unit of oxalacetic decarboxylase is that quantity of enzyme that causes an increase over the blank of 1 μl. carbon dioxide in 10 min. at 25° C.[9]. The blank value, due to the spontaneous decomposition of oxalacetate, was approximately 32 μl./10 min. One unit of oxalacetic decarboxylase was equivalent to 0·78 unit 'malic' enzyme under the stated experimental conditions.

The enzyme preparations used here were obtained by treating whole or dialysed silkworm blood from fifth-instar larvæ with ammonium sulphate and collecting the fraction separating between 40 and 50 per cent saturation. The precipitate from 15 ml. whole blood or 30 ml. dialysed blood was dissolved in 5 ml. water and suitable aliquots were used for the assay of the 'malic' enzyme and oxalacetic decarboxylase.

The results given in Table 1 illustrate that preparations possessing 57–100 units of 'malic' enzyme activity do not show equivalent oxalacetic decarboxylase activity and, like the *Ascaris lumbricoides* enzyme[7], do not catalyse the decarboxylation of oxalacetate. The data in Table 1 also show that no activation of oxalacetic decarboxylase by triphosphopyridine nucleotide occurred with a preparation of the silkworm blood 'malic' enzyme, although it has been reported that small quantities of triphosphopyridine nucleotide stimulate the oxalacetic decarboxylase activity of the pigeon liver 'malic' enzyme[10] and inhibit that of the wheat germ[5].

Table 1. Oxalacetic Decarboxylase and 'Malic' Enzyme Activity of Silkworm Blood Preparations

Preparation*	'Malic' enzyme (units)	Oxalacetic decarboxylase			
		Assay period (min.)	Units		
			No TPN	TPN 0·05 μmole	TPN 0·1 μmole
DB-25	57	4–10	3·0		
		10–15	0·0		
DB-26	83	2·5–5·0	0·0		
		6–10	1·0		
		10–15	1·0		
P-2	100	0–9	2·0	−3·0	−3·0
		10–15	2·0	−2·0	0·0
		15–20	2·0	0·0	−2·0

* The preparations were obtained, as described in text, by ammonium sulphate fractionation of dialysed (*DB*-series) or whole (*P*-series) silkworm blood.

It is concluded that oxalacetic decarboxylase is not associated with the 'malic' enzyme of silkworm blood.

P. Faulkner

Laboratory of Insect Pathology,
Sault Ste. Marie,
Ontario.
June 28.

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Ortho-Tyrosine in an Insect Cuticle

An examination of a developing insect cuticle by means of paper partition chromatography has shown that the changes taking place in amino-acid composition primarily concern the aromatic members. Larval cuticles of *Calliphora vomitoria* have been hydrolysed at different stages of development in 6 *N* hydrochloric acid and chromatograms developed using butanol/acetic acid/water and phenol saturated with water as solvents. The positions of the amino-acid spots were located by spraying with ninhydrin. At all stages the following amino-acids were recognized: alanine, arginine, glutamic acid, glycine, leucine, lysine, proline, serine, threonine, and valine. In addition, tryptophan is present before the onset of puparium formation. The chief differences between the various developmental stages concern the presence or absence of phenylalanine and *para*-tyrosine. At the concentration of hydrolysate used, phenylalanine is only very faintly distinguishable in the cuticles of four- and five-day old larvæ; but in the seven-day old and white puparial cuticles it is abundant. Thereafter, however, in the one-day old and fully hardened puparia, it is absent. Somewhat similarly, *para*-tyrosine is present at all stages up to, and including, the white puparium, but is absent from the hardened puparial cuticle.

In addition, however, to phenylalanine and *para*-tyrosine, the cuticle of the seven-day larva yields a spot, not found in any of the other stages, which is indistinguishable from that given by an authentic sample of *ortho*-tyrosine. This appears to be the first indication of the presence of *ortho*-tyrosine in an insect cuticle, and in view of the roles which have been attributed to tyrosine in the development of the cuticle[1], this distinction between *ortho*- and *para*-tyrosine is clearly important. It is possible that the disappearance from the chromatograms of ninhydrin-positive spots corresponding to phenylalanine and *para*-tyrosine may be an indication of the participation of the amino-groups of these acids in the tanning process. But *ortho*-tyrosine disappears not only before this process begins, but even before the white puparium stage is reached; and its appearance and disappearance at about seven days may well be correlated with the preparation of the cuticle for the later hardening process.

I am grateful to Dr. C. E. Dalgliesh for the gift of an authentic sample of *ortho*-tyrosine. This investigation into the amino-acid metabolism of a developing insect cuticle is being continued, and a full account will be given in due course.

R. DENNELL

Department of Zoology,
University, Manchester.
Aug. 10.

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Inhibition of Luminescence by Sodium Diethyldithiocarbamate and its Recovery by Sodium Borate in Luminous Bacteria

RECENTLY, significant roles of heavy metals which affect pigment formation in various animals have been examined in this laboratory[1,2].

I have investigated the effects of various metals and metal-chelating compounds on the luminescent reaction in a luminous strain, *Photobacterium phosphoreum*. The bacteria were cultured for 18 hr. in the nutrient medium at 25° C. Cells were harvested by centrifugation and suspended in 3 per cent sodium chloride solution. This suspension emitted a very brilliant light continuously for several hours, but if sodium diethyldithiocarbamate solution was added to this suspension (final concentration 10^{-3}–10^{-4} *M*), the luminescence ceased or decreased rapidly in a few seconds.

Among many kinds of metal-chelating compounds thus far tested, namely, sodium diethyldithiocarbamate, diphenylthiourea, ethylenediamine tetra-acetate, 8-oxyquinoline, phenylthiourea, thiourea and thiouracil, the first was the most effective in stopping the bacterial luminescence. This inhibitory effect was eliminated by addition of certain metal solutions such as ferric chloride, cupric chloride, zinc chloride and sodium pyroborate.

Among the metal solutions thus far tested, sodium pyroborate solution was the most effective in the recovery of luminescence, and boric acid was as active as 60 per cent of sodium pyroborate in an equimolal concentration. Sodium diethyldithiocarbamate solution to which sodium pyroborate was added previously has little effect on the luminescent reaction.

Sodium diethyldithiocarbamate solution has two absorption maxima at 255 mμ and 280 mμ respectively; but these peaks disappear when cupric chloride is added to the solution. On the other hand, sodium pyroborate shows no effect on the elimination of these peaks. Therefore, the concentration of sodium diethyldithiocarbamate may be estimated spectrophotometrically by examination of these absorption peaks in the case where sodium pyroborate is used.

Equal volumes of luminescent bacterial suspension were put into four tubes. Sodium diethyldithiocarbamate solution was added to the first and second tubes so that the final concentration was equal. After the luminescence of both tubes disappeared, sodium pyroborate solution was added to the first tube and the same volume of distilled water was added to the second tube as a control. The luminescence of the second tube was recovered as described before. Then the bacterial cells were removed from these four tubes by centrifugation.

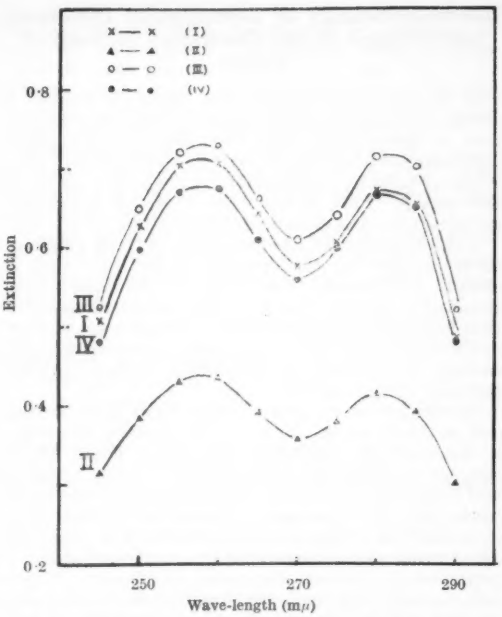

Fig. 1. Absorption spectrum of sodium diethyldithiocarbamate in the supernatant of the first tube (I), the second tube (II), the third tube (III) and the fourth tube (IV). The concentration of the carbamate and sodium pyroborate used is 10^{-4} *M*

After centrifugation, sodium diethyldithiocarbamate solution was added to the third and fourth tubes so that the final concentration was the same as before. Then sodium pyroborate solution was added to the third tube and the same volume of distilled water was added to the fourth tube.

These supernatants were assayed spectrophotometrically. The result (Fig. 1) shows that sodium diethyldithiocarbamate concentration in the supernatant layer of (II) is lower than that of (IV), but sodium diethyldithiocarbamate concentration in the supernatant layer of (I) is nearly equal to that of (III). This means that sodium diethyldithiocarbamate which is added to the bacterial suspension is absorbed by bacterial cells and removed with them by centrifugation, but it is liberated from the cells into the supernatant layer when sodium pyroborate is added.

The luminescent bacterial cell to which sodium pyroborate was previously added was not affected by the subsequent addition of sodium diethyldithiocarbamate; but the effect of this compound was as active as the untreated cells when the cells were centrifuged and freed from sodium pyroborate prior to the addition of sodium diethyldithiocarbamate.

Judging from these results, it may be assumed that the recovery of luminescence by the sodium pyroborate is due to the removal of sodium diethyldithiocarbamate from the bacterial cells.

TEIJI IIJIMA

Department of Genetics,
Faculty of Medicine,
Osaka University,
Osaka.

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Interrelationships of Germination Inhibitors and Oxygen in the Dormancy of Seed of *Betula*

It has been shown that for 'seeds' (achenes) of *Betula pubescens* a much higher percentage germination is obtained in long days than in short days (approximately 90 and 25 per cent respectively)[1]. The effect of light is presumably on the living tissue of the embryo; but it has been found that excised embryos germinate even in complete darkness.

The alteration of the response of light-sensitive seeds to light by the removal of the seed coat is already well known; but we are still far from understanding the cause of this. It has been demonstrated that in some seeds, germination inhibitors are located in the seed coat, and it has been suggested that the embryo is allowed to germinate because of the removal of the inhibitor.

Investigations on this problem have been carried out on birch seeds. It has been possible to obtain a water-soluble inhibitor from these seeds which strongly inhibits the germination of birch embryos and lettuce seed. In later experiments extracts were made using 100 per cent methanol as solvent, thus avoiding the extraction of proteinaceous material. The extract was chromatographed on Whatman No. 1 paper using a solvent composed of 99 parts 70 per cent aqueous *iso*propanol to 1 part ammonia (specific gravity, 0·880). Using excised birch embryos (in the dark) (Fig. 1) and lettuce seed (var. Newmarket) for bio-assay, a non-fluorescent inhibitor has been located running between R_F 0·7 and 0·9. It was possible to extract seeds both with and without embryos, and the same inhibitor was found in both these samples, thus indicating that it must be present in the pericarp. When the embryos are planted on filter paper soaked in the inhibitor, no germination occurs in the dark, but the inhibition is overcome when the embryos are exposed to light.

The question arises as to whether this inhibitor is of functional significance in controlling the dormancy of the seed. Experiments carried out on seeds from which some, but probably not all, of the inhibitor has been leached, show that the photoperiodic response is altered by this treatment, giving a high percentage germination even in short days (70 per cent). It is not possible, however, to obtain any germination of leached seeds in the dark.

It is known that in some seeds the enclosing structures restrict the inward diffusion of oxygen[2]. One of the effects of seed-coat removal in birch, therefore, apart from the removal of the inhibitor, might be to make more oxygen available to the embryo. By slitting the pericarp and endosperm it is possible to allow of the entry of oxygen but at the same time maintain the inhibitor around the embryo. After this treatment, approximately 50 per cent of the seeds germinate in the dark, whereas intact seeds do not germinate at all. It is clear, therefore, that the behaviour of the seeds is profoundly modified by slitting the seed coat even though the inhibitor is still present. Furthermore, it was later found that approximately 20 per cent germination could be brought about in the dark simply by making one scratch, the length of the seed, in the pericarp. The results of a number of experiments suggest that these effects are due to enhanced oxygen entry, since it is possible to secure 100 per cent germination of both slit and scratched seeds in the dark if the oxygen concentration is increased to 50 per cent. Moreover,

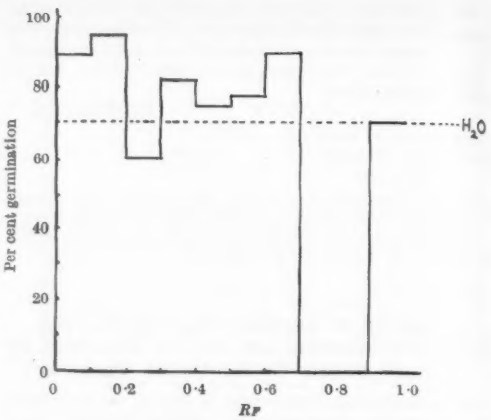

Fig. 1. Bio-assay of the chromatogram of a methanol extract of birch seed

the photoperiodic response can be altered by increasing the oxygen concentration. In an atmosphere of 50 per cent oxygen, 70 per cent germination occurs in short days compared with 15 per cent for the control in air.

There appear, therefore, to be two results of removing the seed coat. First, the embryo is brought into direct contact with atmospheric oxygen, and secondly, the inhibitor is removed. Presumably intact seeds do not germinate in the dark because of the presence of the inhibitor and also because the seed coat restricts the entry of oxygen.

A direct connexion between the influence of the inhibitor and the effect of oxygen is provided by the results of experiments performed with leached seeds. Scratching the pericarp of unleached seeds results in approximately 20 per cent germination in the dark in air. However, if leached seeds are scratched, the percentage germination in the dark, in air, is of the order of 60 per cent.

Thus it would seem that when some inhibitor is removed, the ordinary atmospheric oxygen tension is sufficient to promote the germination of many more scratched seeds in the dark and it is even possible to secure the germination of some, although only a small percentage, of intact leached seeds in the dark in higher oxygen tensions. Furthermore, it has been found that although completely isolated embryos germinate in the dark, in atmospheres containing only 1 per cent oxygen, the minimum oxygen requirement for germination is very much higher if the pericarp is still present, even though this has been cut away so as to bring the embryo into direct contact with the surrounding atmosphere.

One possible explanation of these results is that oxygen is involved in the deactivation of the seed-coat inhibitor, possibly by oxidation mediated by an enzyme system. On the basis of this hypothesis, it is easy to understand that although, in slit seeds, the inhibitor is still present and presumably diffusing inwards to the embryo, oxidation of the inhibitor is taking place at the same time. In scratched seeds, in air, sufficient oxygen is not entering to remove the inhibitor. But if the inhibitor has been previously leached out, the minimum oxygen requirement is less, and greater germination of scratched seeds occurs in air.

This is in agreement with results obtained by Wareing and Foda[3], who found that the inhibitor present in *Xanthium* embryos disappears in high oxygen tensions, before any visible germination changes have taken place. Furthermore, they have been able to obtain an enzyme preparation from the embryos which is capable of destroying the inhibitor *in vitro* in the presence of oxygen.

By analogy, the evidence presented above for birch seed would justify the assumption that a similar basic mechanism is operative in these seeds also, although, as yet, it has not been possible to demonstrate this.

It is unlikely that the role of light is in the destruction of the inhibitor, since one would not expect any photoperiodic effects if this were true[1]. It is more probable that light is directly involved in the production of a promotive agent which can overcome the effect of the inhibitor.

M. Black

Department of Botany,
University of Manchester.
Aug. 2.

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Glutamic Acid Decarboxylase in Legumes

Since the pioneer researches of Okuniki[1,2] and Schales and his associates[3-5] on glutamic acid decarboxylase, rather scanty data have been made available on amino-acid decarboxylases of plants. Most of the work deals with glutamic acid decarboxylase of higher plants; so it was thought of interest to study the enzyme system in the case of dry seeds of legumes.

The assays were carried out by means of Warburg manometric measurements at 35° C. Healthy, well-formed seeds were freed of contamination, if any, by thoroughly cleaning them with permanganate solution followed by copious amounts of distilled water. These were dried, finely powdered and stored in sterile bottles in a refrigerator. 3 gm. seed powder was extracted with 100 ml. *M*/15 phosphate buffer (*p*H 5·8) for ½ hr. at room temperature (28° C.). The extract was then passed through muslin and the activity of 4·0 ml. suspension was determined.

Of the leguminous seeds investigated, field bean appears to be the richest source of glutamic acid decarboxylase and is being used for the preparation and purification of this enzyme. In this bean, the product of decarboxylation was identified as γ-amino-butyric acid by paper chromatography. Field bean extract lost its activity on dialysis at 4° C. for 18 hr., which could be partially restored by addition of pyridoxal-5-phosphate. Addition of pyridoxal phosphate to the original extract was also found to enhance its activity considerably. This activating influence of pyridoxal phosphate suggests that the same is the coenzyme of the decarboxylase.

Table 1

Seed	Botanical name	Activity c.mm. CO_2/20 min./ gm. dry seed
Field bean	*Dolichos lablab*, L.	1,180
Double bean	*Vicia faba*, Möench	97·54
Aconite bean	*Phaseolus aconitifolius*, Jacquin	95·72
Cow-pea	*Vigna catjang*, Walp.	306·1
Green pea (Indian variety)	*Pisum sativum*, L.	30·24
Black pea (Black variety)	*Pisum arvense*, L.	28·30
Bengal gram	*Cicer arietinum*, L.	95·96
Green gram	*Phaseolus aureus*, Roxb.	346·9
Lentil	*Lens esculenta*, Möench	nil
Red gram	*Cajanus indicus*, Spreng.	58·2

Further studies on the purification of the field bean glutamic acid decarboxylase are in progress. The leguminous seeds are also being tested for other amino-acid decarboxylases.

We are thankful to Dr. K. V. Giri for the gift of γ-amino-butyric acid and to the Government of India for the award of a senior research scholarship to one of us (L. K.).

Leela Kulkarni
Kamala Sohonie

Department of Biochemistry,
Institute of Science,
Bombay 1.
June 30.

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Endosperm and Seed of *Wolffia*

Since the days of Hegelmaier[1] there has been little or no work on the embryology and seed structure of *Wolffia*. Recently[2], I pointed out the probability of a cellular endosperm in this genus. Later, the occurrence of a cellular endosperm was also confirmed in *Lemna paucicostata*[3], which contradicts Lawalrée's[4] report of a helobial endosperm in *L. minor*.

Abundant flowering material of *Wolffia microscopica*, available at Delhi, has enabled me to make further observations on the endosperm and seed structure of this plant. The first division of the primary endosperm nucleus is followed by a transverse wall resulting in the formation of a micropylar and a slightly smaller chalazal chamber (Fig. 1). At this stage the zygote is still undivided. Next, there is a transverse division in the chalazal and a vertical division in the micropylar chamber (Fig. 2); meanwhile, the zygote has divided to form the 2-celled proembryo. No free nuclear divisions occur at any time.

An interesting point concerning the structure of the mature seed is that the inner integument is completely crushed except at the micropylar end, where its apical portion forms the so-called operculum. The outer integument persists but comprises only a couple of layers, of which the outer develops reticulate thickenings.

Most of the endosperm is consumed; only one layer remains and surrounds the embryo. The cells are packed with reserve food materials except in the chalazal region.

The embryo presents a striking resemblance to that of *Lemna*. While still enclosed within the seed, it has already produced the first frond (f_1) as well as its daughter frond (f_2); and even the initials of the granddaughter frond (f_3) are recognizable. Fig. 3 shows a longitudinal section of the mature seed in which the frond has been cut in a plane at right angles to its flat surface. It is attached to the main body of the embryo by a very short pedicel. On one side it is enclosed by the 'suspensor' and on the other by the 'cotyledonary sheath'. Fig. 4 is an adjacent section in which the outline of the daughter frond

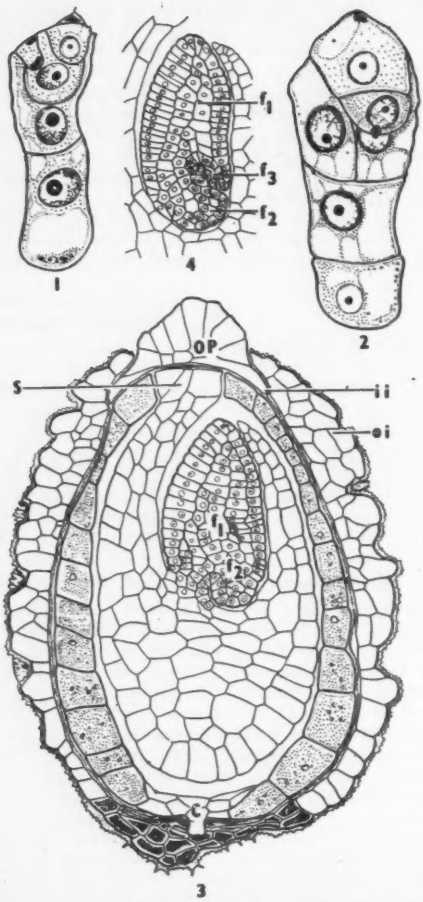

Fig. 1. Longitudinal section of ovule showing zygote and two-celled endosperm; one synergid, remnants of the pollen tube and the degenerating antipodals are also seen (× 450). Fig. 2. Two-celled proembryo and four-celled endosperm (× 450). Fig. 3. Longitudinal section of mature seed; note the first frond (f_1) and its daughter frond (f_2) (× *c.* 166). Fig. 4. Part of a successive section of the same seed showing also the granddaughter frond (f_3) (× *c.* 166). (*c*, Caecum; f_1, first frond; f_2, daughter frond; f_3, granddaughter frond; *ii*, inner integument; *oi*, outer integument; *op*, operculum; *s*, 'suspensor')

is more distinct, and the initials of the granddaughter frond are also recognizable. No root primordium could be distinguished.

The data presented above preclude any close relationship between the Lemnaceae and the Helobiales, as suggested by Lawalrée[4,5]; on the contrary, they support the view that the Lemnaceae are closely allied to the Araceae.

Thanks are due to Dr. B. M. Johri for his interest in the investigation.

Satish C. Maheshwari

Department of Botany,
University of Delhi,
Delhi 8.
Aug. 18.

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Foliar Zinc and *Oidium heveae* in Ceylon

Oidium heveae is a major pathogen on *Hevea brasiliensis* in Ceylon. Following the private communication of results on zinc deficiency in this connexion, since published by Bolle-Jones and Hilton[1], investigations were undertaken to see if this discovery had a practical bearing on the problem in Ceylon.

Three clones of *Hevea brasiliensis* were selected, namely, *LCB* 870, a high-resistant low-yielding strain; *PB* 86, a medium-resistant high-yielding strain; and *Tjir* 1, a highly susceptible, high-yielding strain. Five trees were selected from each clone and representative leaf samples taken, each sample being treated and analysed separately.

Two samplings were made at a fortnight's interval towards the end of the *Oidium* season. The first sampling was vacuum-oven dried and wet ashed with nitric and perchloric acids. The leaf content of zinc is expressed on the oven-dry basis. The second sampling was dry ashed in silica crucibles, and the leaf content of zinc for this sampling is expressed on the fresh weight.

Zinc was determined by the mixed colour dithizone method according to Sandell[2] using a *DU* spectrophotometer.

Tables 1 and 2 show the results obtained.

Table 1. Leaf Content of Zinc in *Hevea brasiliensis* as p.p.m. of Oven-dry Tissue

Sample	*LCB* 870	*PB* 86	*Tjir* 1
1	40	23	29
2	20	28	28
3	26	17	31
4	29	26	36
5	36	26	28
Average and S.E.	30·2 ±2·5	24·0 ±2·5	30·4 ±2·5

Table 2. Leaf Content of Zinc in *Hevea brasiliensis* as p.p.m. Fresh Tissue

Sample	*LCB* 870	*PB* 86	*Tjir* 1
1	3·6	4·2	4·7
2	2·4	6·6	4·2
3	2·4	5·7	6·1
4	3·6	4·7	5·7
5	4·7	3·3	4·2
Average and S.E.	3·54 ±0·47	4·90 ±0·47	4·98 ±0·47

There is no statistical significance in either result, though in Table 2 *Tjir* 1 is almost significantly greater than *LCB* 870 at about 18 : 1. The results are not completely conclusive in that, to obtain strictly comparable samples, leaves which had fully matured were selected. *Oidium heveae* in Ceylon is of primary importance in its attack on leaves up to the half-mature stage, when it causes defoliation. At the later stages only severe distortion of the leaf results from the attack. However, these leaves are comparable with those used by Bolle-Jones and Hilton, and it does not seem likely that the clone *Tjir* 1 could, in the course of the previous 20–30 days life of the leaf, have had a zinc concentration of the order one-eighth to one-tenth that of either of the other clones.

This work does not appear to support an alternative hypothesis for inter-clonal differences in *Oidium heveae* resistance to that already proposed by

Young[3], namely, that rate of cuticle thickening in the immature leaf is the determinant factor in the field.

D. H. CONSTABLE

Rubber Research Institute of Ceylon,
Agalawatta.
June 8.

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Plant Life in the Vindhyans

THE possibility of the existence of plant life in the Vindhyans is a century-old problem and it begins with the report of the discovery of coal by Franklin (1833)[1]. Since then investigations have been carried out by various workers, though no definite existence of vascular plants in the Vindhyans could be established until 1950, when Ghosh and Bose[2] reported on their recovery of pitted woods and monolete spores in an Olive shale of the Semri Series (lower Vindhyans). Three years later, Jacob, Jacob and Shrivastava[3] found, in specimens of Jones's original collection of Suket shales, fragments of woody elements and five or six types of spores belonging probably to the primitive pteridosperms and pteridophytes and to doubtful primitive gymnosperms. They did not, however, recover winged spores or those with surface ornamentation in their material.

Recently, I had the opportunity for examining nineteen Vindhyan rock specimens, of which five belonged to the Kaimur Series (upper Vindhyans) and the rest to the various stages of the Semri Series of the Vindhyan system. These samples were obtained through the courtesy of the Geological Survey of India. Following the usual process of maceration in Schultze solution with every possible measure against laboratory contamination, I found a wealth of vascular microflora in fifteen out of the nineteen of the above specimens, the four barren samples being an Olive shale (Semri Series), two Porcellanites rocks (Semri Series) and one Bijaigarh shale (Kaimur Series). The detailed results of this work will be published elsewhere.

The main object of this note is to report on the occurrence of winged spores or those with surface ornamentation in the Vindhyans, more particularly in the Semri. The following is a descriptive list of a few of such spores.

1. *Microreticulate spore.* 44μ in diameter, brownish-yellow in colour, surface reticulate, lumen of the net 2–3 5μ in diameter; spore wall is not clearly seen and the spore body is somewhat distorted (Fig. 1).

2. *Punctate monolete spore.* 27·5μ × 37·4μ, yellow in colour, body densely pitted or reticulate with a bulging slit of dehiscence which is 33μ long; bulging-ends 3·3μ wide, spore wall is not clear (Fig. 2).

3. *Cingulate trilete spore.* Spore axis 88μ; yellow; slit axis 33μ long and 9–11μ broad; slit-rim 2μ thick; slit opening or aperture 5·5 μ; body provided with concentric ridges; spore body brownish in colour; spore wall 1μ thick; flange 3·5μ wide, yellow and wavy (Fig. 3).

4. *Monosaccate spore.* 114μ × 60μ; body distorted; frill is 9–11μ wide, brownish-yellow, longitudinally reticulate and attached to a thick rim; the rim is deep brown in colour and is 2–2·5μ wide (Fig. 4).

5. *Monosaccate spore.* 109μ × 88μ; spore body 77μ × 55μ, pale yellow in colour; frill is dark brown, longitudinally reticulate, 18μ wide approximately, but is not attached to any rim-like structure (Fig. 5).

6. *Disaccate spore.* 42μ in extension, spore body 23μ × 23μ, yellow in colour; wings reticulate, 16·5–15·5μ × 23–22μ in size (Fig. 6).

7. *Disaccate striate spore.* 44μ in extension; spore body 15·4 × 18·7μ, brown in colour, body spirally thickened with stripes; wings yellow, reticulate, 17·6μ–22μ × 25·3–22μ in size, base of wings 2·5μ thick (Fig. 7).

8. *Disaccate striate spore.* 49·5μ in extension, body 24·2μ × 33μ in size and is provided with six stripes which are more or less equidistant and 1·5–2·5μ thick, each extending in a curved manner to meet the spore wall on either side; colour, golden-yellow; wings 23μ × 33–28·5μ (Fig. 8).

Of the spores recovered, the saccate types have been found to occur abundantly in the Kheinjua stage (Semri Series) and very sparsely in a limestone from the Rohtas stage (Semri Series) and another specimen of Kajrahat limestone (Semri Series); the trilete ones occur in abundance in the Kheinjua and Rohtas stages, very rarely in the lower Kaimur and are completely absent in the Upper Kaimur and the basal stage of the Semri Series. It may be recalled

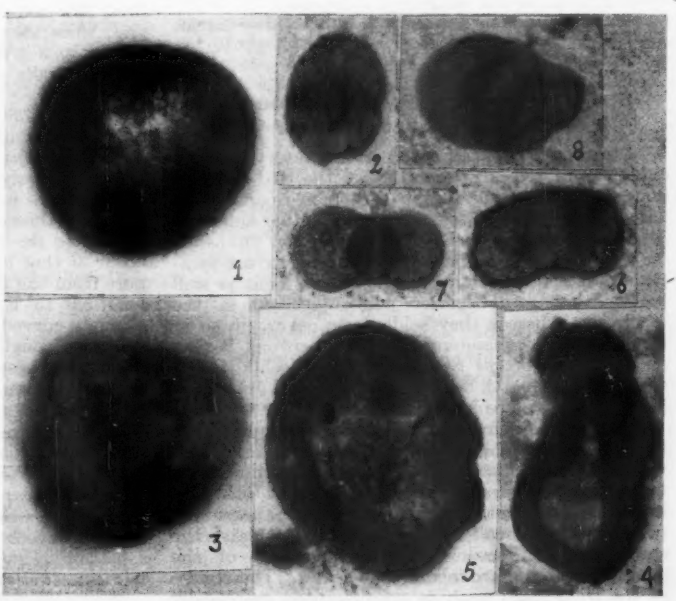

Fig. 1, × 800; Figs. 2–8, × 360

that (*a*) winged spores have been recorded in the Upper Cambrian of Spiti, Middle–Upper Cambrian of Kashmir by Jacob *et al.*[4] and the Cambrian of the Punjab Salt Range and Kashmir by Ghosh and Bose[5–7] and Bose[8]; (*b*) deltoid trilete spores have been found in the Cambrians of the Punjab Salt Range, and also in the Middle Cambrian of the United States by Ghosh and Bose[9]. On comparison, therefore, it may be suggested that the Kheinjua and Rohtas stages (Semri Series) are Middle–Upper Cambrian in age, with the consequence that (1) the Basal and the Porcellanites stages of the Semri Series become Lower Cambrian, and (2) the Kaimur Series, the Rewah Series and the Bhander Series become Late Upper–Post-Cambrian in age.

Specimens of Suket shales on which Jacob *et al.* carried out their investigation belonged to the upper part of the Semri Series; but I have done my work, as pointed out earlier, with material belonging both to the Upper and Lower Vindhyans. The various types of spores listed above prove beyond doubt that a well-developed flora of the Archegoniate group thrived in the Vindhyans and that "the Vascular land plants were in existence even as early as the Lower Cambrian"[3].

Thanks are due to Sri A. K. Ghosh for his guidance, to Dr. D. M. Bose, director of the Bose Institute, for giving laboratory facilities, and to Sri K. L. Chowdhury for photographing the plates.

A. Bose

Bose Institute,
Calcutta.
June 23.

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Status of the Two Forms of Housefly occurring in South Africa

Although evidence[1], based on laboratory crossing experiments, exists for considering the two forms of housefly which occur in the Ethiopian region to be only subspecifically distinct from each other and from *Musca domestica s. str.*, nothing has been published on how they interact in Nature when they are sympatric. It is important to know this, as it is well known that some species will interbreed in the laboratory whereas they seldom, or never, do so in Nature. The behaviour of *M. cuthbertsoni* Patton and *M. curviforceps* Saccà and Rivosecchi[1] (*vicina* auct. not Macquart), both of which occur at Johannesburg, has therefore been investigated.

Synchronous samples of the domestic population (caught in and immediately outside buildings) and the feral population (caught well away from buildings) were made on a farm some thirty miles from Johannesburg. The frons ratio (width of frons at the narrowest point/width of head at the widest point) and the shape of the paralobi (inferior forceps) of the genitalia were determined for all males. The results of the frons ratio analysis are presented graphically in Figs. 2 and 3. These and the study of the paralobi

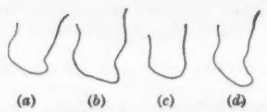

Fig. 1. Paralobi: (*a*) Hybrid. (*b*) *M. domestica curviforceps* (Johannesburg). (*c*) *M. domestica cuthbertsoni* (Johannesburg). (*d*) *M. domestica curviforceps* (Tongaland)

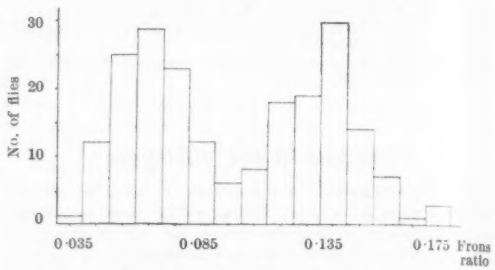

Fig. 2. Frequency distribution of the frons ratio in houseflies (domestic and feral) on a farm near Johannesburg

revealed that *curviforceps* occurred mainly in the domestic environment and *cuthbertsoni* mainly in the fields. Thus they are more or less ecologically isolated. Many males in both populations had, however, paralobi which were intermediate in shape between the two typical forms (Fig. 1). Since I have found that laboratory hybrids between these two forms have paralobi of intermediate shape, this is interpreted as indicating that natural hybridization does occur. These results have been confirmed by subsequent collections.

This evidence of the occurrence of natural hybridization between *cuthbertsoni* and *curviforceps* indicates that they are not specifically distinct, despite the fact that they are often sympatric in the original sense of the term.

Musca domestica s.str. and *curviforceps*, I can confirm, are completely interfertile in the laboratory, and, since they are allopatric, it is convenient, for the reasons given by Mayr[2], to consider them only subspecifically distinct despite their morphological differences.

It is possible that *cuthbertsoni* and *curviforceps* are now often sympatric because of extensions of range by *curviforceps* as a follower of man.

While studying the paralobi of Johannesburg *curviforceps*, it was noted that they were not as curved as those of the type series. This, I believe, may be due to the hybridization which I have shown to occur at that locality. This view receives some support from the fact that in Tongaland (lat. 27° 9′ S.; long. 32° 15′ E.) a population occurs which has very strongly curved paralobi as in the type series. These flies were caught in and about the tents of a camp in the bush. A search for *cuthbertsoni* proved fruitless. An alternative explanation is that the flies with

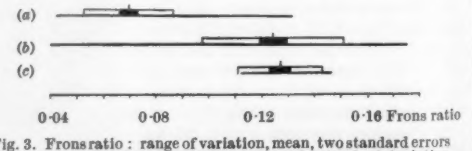

Fig. 3. Frons ratio: range of variation, mean, two standard errors of the mean on either side of the mean, and a standard deviation on either side of the mean for: (*a*) feral population, Johannesburg ($n = 99$); (*b*) domestic population, Johannesburg ($n = 109$); (*c*) domestic population, Tongaland ($n = 44$)

strongly curved paralobi are linked by an altitudinal cline to those with moderately curved paralobi. This alternative will be tested by further collecting.

A full report of this work will be published in due course. I am indebted to Prof. G. Saccà for help in various ways.

H. E. PATERSON

South African Institute for Medical Research,
Johannesburg. May 23.

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Occurrence of *Polydora pulchra* Carazzi in British Waters

WHILE studying the seasonal variation in plankton and hydrography of the plaice ponds at the Marine Biological Station, Port Erin, I came across a dense population of larvæ belonging to the species *Polydora pulchra* Carazzi (Polychaeta Spionidae). The identification is based on the key, descriptions and figures given by Hannerz[1]. The identification was further confirmed when the larvæ metamorphosed in the laboratory.

Carazzi[2] was the first to describe *pulchra* as a variety of *Polydora antennata* Claparède; but recently Hannerz[1] separated the variety and classed it as a distinct species with the name *Polydora pulchra* Carazzi. There are no previous records of either *Polydora antennata* or *Polydora pulchra* in British waters (Tebble, N., personal communication). Adult specimens have not yet been found in British waters.

Polydora pulchra has been very rarely reported. The only records are those of Fauvel[3] and Hannerz[1]. Fauvel found the species in the Mediterranean at Naples and in the Atlantic off northern Spain, while Hannerz found three individuals in southern Sweden. The occurrence of *Polydora pulchra* at Port Erin thus extends the known distribution of the species into the Irish Sea. Observations on the behaviour of the larvæ of *Polydora pulchra* and their resistance to changes in temperature, *p*H and salinity are being published elsewhere.

I wish to thank Dr. N. S. Jones, of Port Erin, and Mr. Norman Tebble, of the British Museum (Natural History), for confirmation of the identity of the larvæ.

M. R. RANADE

Marine Biological Station,
Port Erin, Isle of Man.
July 25.

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An Unusual Method of capturing Prey by a Cuttlefish

IT is usually assumed that the typical shallow-water decapod cephalopods are active hunters and seek out their prey rather than wait for the prey to come to them. It does sometimes occur[1] that a cuttlefish is lying passive, half buried in the sea bottom, and that when food, such as a prawn or a crab, passes close by, the tentacular arms are rapidly unfurled in an attempt to secure the prey. In contrast to these methods, I was fortunate enough to observe a cuttlefish actively luring fish to within reach of the tentacular arms.

The observation was made in the late afternoon in the Straits of Singapore, some six miles offshore, from the Fisheries Research Station's launch, the *Chermin*, during the interval between two of the routine series of plankton hauls which are made in this area. At the time, the engine was shut off and the boat was drifting with the tide in a fairly extensive patch of *Sargassum* weed. The sea was glass-calm.

Through a break in the weed a small cuttlefish of about six inches length could be seen, floating some twelve inches below the surface. It was lying horizontally, the arms typically bunched together, there being no sign of any movement except from the suckered tips of the tentacular arms. These were extended above the head, inclined slightly forward, straight, excepting the distal suckered portions, and were slightly divergent. Both the tips of the tentacular arms were pendulous and slowly waving about in the water. Since the water was so perfectly calm, and there being no movement of any part of the submerged fronds of the *Sargassum* weed, it is reasonable to assume that the cuttlefish was waving them. This assumption is supported by the distribution of colour over the body. All the body, excepting the suckered areas of the tentacular arms, was of a uniform dull brown colour, very similar to that of the *Sargassum* weed. The suckered areas of the tentacular arms were white and very prominent.

It should be added here that I am well acquainted with the appearance of moribund and dying cuttlefish, and the possibility of the cuttlefish discussed here being moribund was considered, and rejected, since there was no indication whatever of it being other than healthy and normal in its behaviour.

Several times during some ten minutes of observation, small fish, which were clustered under the *Sargassum* weed, left their place of shelter to investigate the white tentacle tips. When the fish approached close to the tentacular arms, the cuttlefish attempted to catch them by a sudden dart forwards and securing them with the arms. During the period of observation the attempts were, unfortunately, unsuccessful. The cuttlefish did not exhibit any colour changes when approached by the fish, or when attempting to catch them.

Thus, although the actual capture of the prey was not observed, it was an undoubted case of an animal, accepted as being a hunter of its prey, deliberately and successfully luring its prey to it.

J. WICKSTEAD

Singapore Regional Fisheries
Research Station,
Singapore 17. May 21.

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Influence of Gamma Irradiation on the Breeding Affinities of *Lolium perenne* and *Festuca pratensis*

I HAVE recently carried out investigations to determine the possible influence of gamma irradiation on the breeding affinities of *Lolium perenne* and *Festuca pratensis*. These two diploid species have hitherto been considered to be extremely incompatible[1], although it so happens that during these investigations a number of highly compatible genotypic combinations were found. I was indeed fortunate to have worked with parental material which on crossing showed four distinct levels of

Table 1. The Effect of Pollen Irradiation on Seedset and Germination in Crosses between *L. perenne* and *F. pratensis*

Cross		Dose in roentgen (per cent)					
		Control	250	500	1,000	2,000	3,000
L. perenne (♀) × *F. pratensis* (♂)							
(1) $L_1 \times F_1$	Seedset	77·6	62·8	66·1	59·0	49·0	47·7
	Germination	0·0	0·0	0·0	0·0	0·0	0·0
(2) $L_2 \times F_1$	Seedset	81·5	70·5	65·2	81·1	86·3	73·1
	Germination	10·8	7·6	8·0	11·9	8·8	6·5
(3) $L_3 \times F_1$	Seedset	76·7	73·7	66·0	83·6	78·6	60·8
	Germination	46·3	25·6	6·9	17·3	31·6	20·0
(4) $L_3 \times F_3$	Seedset	76·8	76·3	74·7	76·8	67·4	66·0
	Germination	54·1	46·7	42·1	62·0	64·3	62·7
F. pratensis (♀) × *L. perenne* (♂)							
(5) $F_1 \times L_1$	Seedset	71·7	45·6	50·0	61·3	39·8	25·0
	Germination	0·9	0·0	2·1	1·8	0·0	14·3
(6) $F_1 \times L_2$	Seedset	54·8	73·2	56·6	30·7	43·4	48·0
	Germination	0·0	13·4	7·1	1·1	6·4	0·0
(7) $F_2 \times L_2$	Seedset	61·2	51·6	50·5	51·5	57·6	46·9
	Germination	0·0	0·0	0·0	0·0	0·0	0·0
(8) $F_3 \times L_3$	Seedset	60·3	57·0	50·4	56·2	52·6	50·0
	Germination	0·0	0·0	0·0	0·0	0·0	0·0

L_1, L_2 and L_3, genotypes of *L. perenne*. F_1, F_2 and F_3, genotypes of *F. pratensis*.

compatibility, ranging from combinations where none of the seeds was viable to those in which as many as 50 per cent of the caryopses germinated, that is, a high seed-compatibility[2].

Table 1 summarizes some of the results obtained after irradiating inflorescences of the two species at about 7 days prior to anthesis by means of a cobalt-60 source.

In general there is a significant reduction in seedset after 250–500 r. This is followed by an increase at 1,000–2,000 r.; but further increases in dose again result in a decline.

The effect of irradiation on seed-compatibility, although similar to that observed for seedset, showed a greater variability. Nevertheless, the results still fit into a general pattern if one takes into account first the direction of the cross and secondly the normal seed-compatibility of the genotypes involved.

In the *L. perenne* by *F. pratensis* matings the drop at 250–500 r. as well as the recovery at about 1,000 r. occurred to varying degrees in different crosses: in the normally incompatible cross (No. 1) and in the cross of low compatibility (No. 2), irradiation had little effect; in the cross of medium compatibility (No. 3) the initial drop as well as the increase at 1,000 r. was marked, but where the normal compatibility is high (No. 4) only a small reduction occurred at 500 r. Moreover, in the latter cross the germination percentage at the higher doses significantly exceeded that observed normally. Genotypic differences in the response to irradiation are therefore evident.

In crosses with *F. pratensis* as seed parent genotypic differences were again apparent in that the greater the genetic difference between the genotypes, the greater was the dose required for optimum production of viable seeds; for example, compare crosses (5) and (6). These differences were, however, partly masked by the fact that crosses showing a high degree of seed-compatibility where *L. perenne* was the female parent were not the most successful combination in reciprocal matings; for example, crosses (7) and (8).

While the results in themselves are quite clear, it is difficult without further studies to put forward a completely satisfactory explanation; but the following tentative suggestions may be made. It may be assumed that with doses of up to 500 r. pollen-grain differentiation and germination and pollen-tube growth are not sufficiently affected to prevent fertilization, so that cytologically damaged pollen grains would participate in triple fusion. A proportion of the ovules may, however, undergo immediate degeneration, or else at some time after fertilization[3] the former results in a reduction of seedset, the latter in a decrease of seed-compatibility.

At doses higher than 500 r. selective elimination of the more severely damaged pollen grains presumably occurs either through lack of differentiation and germination[4] or possibly due to a slight disadvantage in rate of pollen-tube growth or by a combination of these factors. In consequence, seedset and germination should be higher than at 500 r.

The variable nature of the seed-compatibility data and especially the dependence of the response to irradiation on genotype suggest that irradiation has a second effect directly concerned with the degree of endosperm development. Since endosperm failure has been shown to be due to the genetic disparity which exists between the genomes of the two species (unpublished), it appears that irradiation induces changes in consequence of which endosperm development and hence germination capacity are improved. Superimposed upon the initial decrease in seed compatibility due to cytological abnormalities, we therefore presumably have changes which improve endosperm development. The latter is dependent on the initial disparity which exists between the genotypes.

The results reported form part of a general investigation into the nature of the differentiation and the barriers to successful hybridization between *L. perenne* and *F. pratensis*. They were carried out under the helpful guidance of Prof. P. T. Thomas.

J. D. H. Reusch

Department of Agricultural Botany,
University College of Wales,
Aberystwyth.
July 10.

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Effects of Changes of Temperature on the Respiration of Certain Crustacea

While much work has been carried out recently[1] on the long-term changes which take place in poikilotherms following a change from one constant temperature to another, little is known about the respiratory changes which take place within a short time after the temperature is altered. The object of the present study was to investigate this. Experiments have been carried out on the following Crustacea: *Neomysis integer*, *Hemimysis lamornae*, eggs of *Astacus pallipes*, *Diaptomus gracilis*. A detailed study was made on *Artemia salina*. The rate of respiration was estimated using a continuous-flow apparatus which will be described elsewhere. Most of the animals were kept for two days or more at the initial temperature of the experiment. They were then put in the apparatus, and after a few hours this was suddenly transferred to a new constant temperature, at which they were kept for a further period, usually a few hours, before finally being

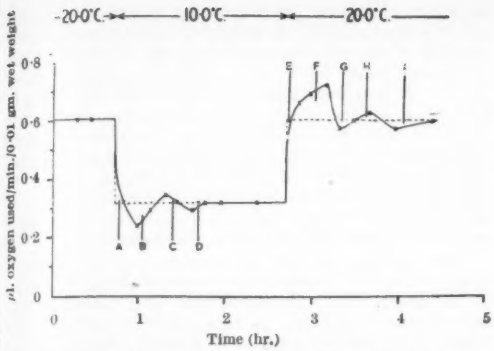

Fig. 1. Graph showing the effect of a change of temperature on the oxygen consumption of *Hemimysis lamornae*. The experimental temperature and the points at which it was altered are shown at the top of the figure

replaced at the initial temperature of the experiment. The oxygen consumption was followed throughout.

In every experiment on all the Crustacea examined it was found that the immediate effect of either a rise or a fall in temperature was to cause an overshoot in the oxygen consumption. This was usually followed by minor oscillations before a steady level characteristic of the new temperature was reached (Fig. 1). In *Artemia* the steady level was maintained for at least nine hours after the temperature was altered.

Overshoot in oxygen consumption following a change in temperature has been previously reported from a number of fish[2], *Cyclops*[3], *Planaria*[4]. It has been found in some individuals of *Astacus*, but apparently not in others[5]. In fish, however, overshoot appears to be of much longer duration than in Crustacea, and several days or even weeks pass before the steady level of oxygen consumption is reached at the new temperature.

It was found that *Artemia* anæsthetized with ether still showed overshoot in oxygen consumption even though all locomotory activity had ceased.

While the overshoot effect was found in all the oxygen consumption experiments, it could not be detected in any of the similar experiments on carbon dioxide output in *Artemia*. Here the steady level of output was reached within a few minutes at the new temperature. Because of the absence of overshoot in carbon dioxide output there are marked fluctuations in the respiratory quotient immediately following a change of temperature (Fig. 2).

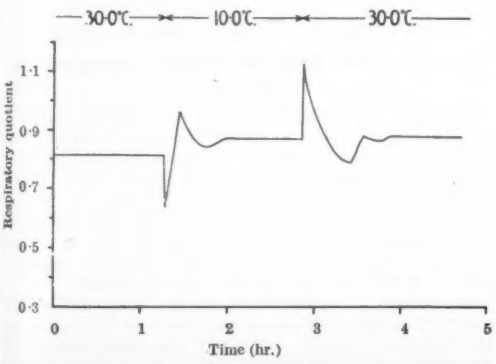

Fig. 2. Graph showing the fluctuations in the respiratory quotient in *Artemia salina* which follow changes of temperature (shown at the top of the figure)

The widespread occurrence of overshoot in oxygen consumption, and particularly its occurrence in the eggs of *Astacus*, suggests that the effect may be inherent in the organization of some organisms or tissues. All the results can in fact be satisfactorily explained if the organism is considered as behaving as a steady-state system. Several authors[6] have pointed out that the metabolism of living organisms can be interpreted in this way. According to steady-state theory the metabolic processes of an animal, when it is kept under constant environmental conditions, should tend to proceed at constant rates. When conditions are altered a new state should eventually be established in which these processes again proceed at constant rates, which are, however, different from the rates in the first state. When the level of oxygen consumption is steady at constant temperature the organism can be considered as being in such a steady state.

The properties of theoretical steady-state systems have been studied in some detail[7]. Many of the systems studied consist of sequences of consecutive or cyclical reactions connected by diffusion with constant external sources and sinks. Even in very simple theoretical systems of this type it has been shown[8] that overshoot curves may occur during the transition between two steady states. Overshoot may occur in such curves showing the relationship between rate of entry of material from an external source and time, when the temperature of the system is changed. It is possible that the observed overshoot in oxygen consumption (Fig. 1) is due to the same sort of reason, namely, a temporary piling up or a deficiency of metabolic substances. If this view is correct the fluctuations in the respiratory quotient (Fig. 2) found experimentally can also be explained, and were in fact predicted from the properties of simple theoretical systems[8]. Furthermore, a 'cost of transition' is to be expected[7,8]. That is, in Fig. 1 ($F + H - E - G - I$) should be greater than ($B + D - A - C$). This was the case in most of the experiments. The mean 'cost of transition' for *Artemia* for the temperature-change 20 → 10 → 20° C. was 0·545 µl. oxygen/0·01 gm. wet weight (mean of three experiments).

It would thus appear that the overshoot effect in oxygen consumption, which has been referred to as 'shock effect'[9], and 'acclimatization'[10] by some authors, can be interpreted satisfactorily in terms of steady-state theory.

These results will be published in detail elsewhere.

J. N. R. Grainger

Department of Zoology,
University, Hull.
July 10.

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Isolation of Active Nematocysts of *Metridium senile* and their Chemical Composition

During the past half-century, there has been recurrent interest in the chemical nature of the stinging capsules of cœlenterates. Mainly two lines of investigation have been pursued. Toxic extracts of the tentacles or whole animal have been examined[1], and histochemical studies have been made. Both these approaches have yielded interesting information for speculation, but as Hyman[2] has pointed out, "On the whole it must be concluded that the nature of the nematocyst toxin is unknown, since the extracts mentioned above include tissues as well as nematocysts . . .", and one cannot expect the histochemical approach to yield the definitive answers.

Since the toxins of nematocysts would be useful substances for testing the immune antitoxic responses of a variety of marine invertebrates, studies were undertaken to find a way of isolating active nematocysts in a purified form and in sufficient quantity to allow chemical analyses and the isolation of the toxin. A method has been found of doing this, and it has afforded some information about the chemical nature of the wall and internal contents of the nematocysts of *Metridium senile*.

Briefly, the method involves maceration of the whole anemones in a Waring blendor with an equal volume of 1 *M* sucrose in sea water (maceration in sucrose solution was originally suggested by Miss Eleanor Dodge, Zoology Department, University of Washington). The creamy suspension is passed through graded screens with openings of 1·168, 0·589, 0·295, and 0·147 mm. with the aid of suction. Tyler standard screens customarily used for geological investigations were fitted on to a Buchner funnel with the aid of masking tape. The suspension after this filtration consists of nematocysts, fine tissue debris, dissolved tissue constituents and very fine sand. The amount of sand can be greatly diminished by keeping the anemones on a wire screen for several days before macerating.

Centrifugation of the suspension at approximately 1,000 rev./min. for fifteen minutes collects the nematocysts, and they are washed with additional sucrose solution to free them of soluble materials. Differential centrifugation in a small International clinical centrifuge finishes the purification. 15-min. centrifugations are used to collect the nematocysts and free them from fine tissue fragments. 15-sec. centrifugations are used to remove the sand. After five or six such centrifugations, the material appears to be all but completely free of both the sand and tissue fragments when examined microscopically, and is chemically consistent from batch to batch with respect to total nitrogen and hexosamine content. The nematocysts may be discharged with distilled water, dilute acid or base, sodium thioglycollate, or methylene blue, and the material released is toxic to those animals tested: the barnacle, *Balanus glandula*, and the snail, *Littorina planaxis*.

Chromatographic analyses of hydrolysates of the walls and tubes after discharge have revealed the presence of eighteen amino-acids: cysteine, aspartic acid, glutamic acid, serine, glycine, histidine, lysine, arginine, threonine, alanine, tyrosine, proline, valine, methionine, phenylalanine, leucine, isoleucine, and tryptophan. Two-dimensional chromatograms were developed with phenol/water (80 : 20), followed by butanol/acetic acid/water (4 : 1 : 5). Isatin and ninhydrin were used for the detection of spots. In addition, a hexosamine resembling galactosamine and a uronic acid resembling glucuronic acid were detected in acid hydrolysates through the use of one-dimensional chromatograms with ethyl acetate/pyridine/water (2 : 1 : 2) and *p*-anisidine hydrochloride or ninhydrin for the detection of spots. Quantitative determinations[3] of these carbohydrates has revealed that they are present in an equimolar ratio which may indicate the presence of chondroitin sulphuric acid; a polysaccharide similar in solubility characteristics has been isolated. These findings suggest that the walls may be formed of a cartilagenous material.

The material released on discharge of the nematocysts in distilled water shows on hydrolysis the same amino-acids, with the exception that tyrosine and tryptophan appear to be lacking. The same hexosamine and uronic acid are present, but in this material they are in a molar ratio of four hexosamines to five uronic acids. It is still uncertain whether the internal mucoproteins are of more than one species. In addition to the mucoprotein material, two hydroxyindoles have been detected. One of these, which is extractable with ether from acidified material, resembles 5-hydroxytryptophan with regard to its colour reactions and fluorescence. The other, which is extractable with ether from basic solutions, resembles bufotenine (N dimethyl 5-hydroxytryptamine) with regard to chromatographic development in basic, neutral and acid solvents. In addition to giving the bluish Ehrlich reaction, it fails to give the greenish-yellow colour of 5-hydroxytryptamine with ninhydrin in acetone. This latter substance has recently been found in tentacle extracts of *Metridium*[1]. Further work is under way on the identification of these substances.

The analyses, which have been carried out to this point, indicate that the material injected into the prey of these anemones is a mucoprotein with either adsorbed or free hydroxyindoles. It is hoped that through the investigation of purified suspensions of nematocysts their nature will be revealed.

John H. Phillips*
Hopkins Marine Station of Stanford University,
Pacific Grove, California. June 15.

* Fellow in cancer research of the American Cancer Society.

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Larvæ of the Polypterid Fish *Erpetoichthys* Smith

When J. S. Budgett studied the *Polypterus* larva in the Niger Delta in 1903, he also searched for larvæ of the closely related *Erpetoichthys*, but did not find any. Apparently later workers have been equally unsuccessful, since there seem to be no records of juvenile *Erpetoichthys*. It was assumed that *Erpetoichthys* would possess a larval stage similar to that of *Polypterus*, with pinnate external gills; but this had not so far been confirmed.

On March 17, 1956, towards the end of the dry season, I caught two young specimens of *Erpetoichthys* at Aiyetoro about 40 km. west-north-west of Abeokuta in south-west Nigeria, both still in the larval condition. The find was made at the point where a small bridge on the Iboro Road crosses a

swamp in the middle of the township of Aiyetoro. The water-level was very low, probably at its lowest, and the brook traversing the swamp was a mere trickle. The swamp itself consisted, at this point, of thick black mud, more than 50 cm. deep and with practically no water above. An enormous growth of *Pistia* was resting directly on the mud surface, the lower layers forming a fairly compact mass of decaying vegetable matter. The two young *Erpetoichthys* were found in a lump of this mud, scooped out of the swamp a few metres from the brooklet and spread on the road.

Before being killed and preserved, the specimens were kept alive in an aquarium for about three weeks at University College, Ibadan. One was about 6 cm. in length, the other about twice as long, and both had well-developed external gills resembling those of larval *Polypterus*. Frequent air gulping seemed to indicate that the lungs were already functional; this took place at short regular intervals, even in well-oxygenated water.

The finding of larval *Erpetoichthys* at Aiyetoro was unexpected as the place was outside the known area of distribution of the species. *Erpetoichthys* is said not to occur west of the Ogun River system; but the small stream draining the swamp at Aiyetoro belongs to the more western Yewa system. Moreover, and probably more important, Aiyetoro is a typical inland locality, more than 80 km. from the lagoon and coastal swamps. This is in contrast to the statements in the literature, which describe *Erpetoichthys* as a coastal form, confined to deltas, lagoons and estuaries[1], and raises the question whether this species migrates inland to spawn. If so, this would explain why searching for its young stages in the coastal region has not been successful.

A more complete account of the observations on larval *Erpetoichthys* will be published elsewhere. Field-work with the aim of throwing light on the distribution and breeding of this species is being continued.

H. Stenholt Clausen

Department of Zoology,
University College, Ibadan,
Nigeria, West Africa.
April 25.

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Rate of Heat Production by Bull Spermatozoa

During some work on a problem unrelated to the present communication, a microcalorimeter was developed based on the 'Callendar Radio-balance'[1]. This calorimeter has been used for measuring the rate of heat production of unbuffered bull semen under anaerobic conditions, and although the calorimeter was not ideally suited to the work some results have been obtained which might be of interest to workers in the field of fertility.

Measurements were made on unbuffered whole semen from a bull of proved fertility. The measurement showed that there was a fall in rate of heat production from approximately 200 micro-watts/ml. of semen at 1 hr. after incubation at 37° C. to approximately 35 micro-watts/ml. of semen at 3 hr. These rates of heat production were, however, close to the sensitivity limit of the micro-calorimeter (measurements made on 0·055-ml. sample) and for this reason the accuracy of the measurement is not high. T. Mann[2] has published a curve showing the normal course of fructolysis in an unbuffered specimen of good quality bull semen at 37° C. From the rate of disappearance of fructose, the rate of heat production has been estimated by making the following assumptions: (1) the process is anaerobic; (2) the principal heat-producing metabolic activity is fructolysis; (3) the semen from the bull on which the fructolysis measurements were made was similar to that on which our measurements were made as regards sperm quality, buffering capacity of semen, initial fructose content, etc.—the sperm density is known to be similar in both samples; (4) the heat liberated (ΔH) in the reaction, 1 gm. mole of fructose to 2 gm. mole of lactic acid, is 23,000 calories (ΔF is approximately −47,000 calories).

The value so obtained for the rate of heat production 1 hr. after beginning of incubation at 37° C. is 160 micro-watts/ml. of semen. The trend of the curve for rate of utilization of fructose compares with that for the measured rate of heat production. The agreement of the measured and calculated values is encouraging and suggests that the method might be used for throwing additional light on the nature of the metabolic process (for example, whether fructolysis is the main energy-producing metabolic process).

It is interesting to compare these figures with an estimate of the energy requirement for spermatozoa *movement* made by Lord Rothschild[3] using formulæ developed by Sir Geoffrey Taylor[4,5]. The estimates, using two separate formulæ, are $3{\cdot}74 \times 10^{-7}$ erg/spermatozoa/sec. and $2{\cdot}04 \times 10^{-8}$ erg/spermatozoa/sec. The details are given in ref. 3 and the approximations in the hydrodynamic treatment are fully discussed in refs. 4 and 5. Our measurement converted to the same units is $0{\cdot}24 \times 10^{-5}$ erg/spermatozoa/sec. It appears, therefore, that on this basis the available chemical energy is much in excess of that required for propulsion.

S. Bertaud
M. C. Probine

Dominion Physical Laboratory,
Lower Hutt,
New Zealand.
July 18.

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Geographical Zonation of Atypical Caryotypes in Shieldbugs

Botanists have postulated polyploidy as an adaptation to cold; but it has been shown that in ferns polyploids occur more frequently in Ceylon than in western Europe[1]. Little or no geographical analysis has been attempted of the occurrence of atypical caryotypes in insects outside the genus *Drosophila*, although in the shieldbug genus *Thyanta* three neotropical species have $2n = 14$ while three Nearctic species have $2n = 16$, 16 and 27 respectively[2].

From a number of sources the published values of the diploid number of 151 shieldbug species have been extracted during the course of a revision of the

Table 1. Geographical Distribution of Diploid Numbers in Pentatomidae

	$2n = 14$	$2n \neq 14$	Total
Tropical and sub-tropical spp.	40	2	42
Temperate spp.	58	19	77
Total	98	21	119

higher systematics of the superfamily. Applying a new classification of Pentatomoidea (unpublished) and deleting species of doubtful determination or uncertain provenance, there remain 119 cytologically known Pentatomidae *sensu stricto*: these may be grouped as in Table 1. The ancestral diploid or type number, which here happens to coincide with the modal number, is 14; $12A + X + Y$ in males.

Inspection of Table 1 shows a statistically significant ($P = 0{\cdot}029$) association of atypical caryotypes with a temperate climate. The systematic positions of the atypical species and the presence of genera with a *Thyanta*-like range and caryotype pattern show that the association is not with a Holarctic distribution or monophyletic block although all the temperate forms so far examined live in the Palæarctic or Nearctic.

The present facts suggest either that: (1) rearrangements accompanying speciation in temperate climates tend, under the influence of some external factor, to be more often associated with gross caryotype changes than is the case in the tropics; or (2) gross changes, when they occur, are differentially selected and confer an enhanced survival value in temperate areas. In attempting an evaluation of these two hypotheses it must be remembered that the behaviour and general biology of shieldbugs show that the tropics provide optimum conditions for the group, while the rich fauna suggests it is also the area of maximum speciation.

Dr. R. E. Blackith, of the Imperial College of Science and Technology, London, has kindly assisted me with the statistical analysis.

Dennis Leston

44 Abbey Road,
London, N.W.8.
July 2.

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Sexual Colour Differences in *Caranx ignobilis* (Forsk.)

Caranx ignobilis (Forsk.), the largest of the Indo-Pacific carangids, is a valued food fish from the East African coast to the Hawaiian Islands. The biology of this fish is being studied by one of us (F. W.), and it has been found that maturity is reached between 500 and 650 mm. standard length.

Routine observations on catches have shown that in specimens more than 500 mm. long there is a difference in colour with sex. The male has a dusky to black body, head and fins. In the female the body and head are pale to silvery, except for slight duskiness on the back. Small black dots may or may not be present on the upper sides of the body. The fins are pale to dusky hyaline.

These colorations refer to living and freshly caught specimens, as some hours later both sexes become a uniform dusky grey.

Sex prediction tests were carried out on a sample of 88 specimens, standard length 500–1,150 mm., and were correct in 90 per cent of cases. These colour differences develop with maturity. Most errors occurred in the size range 500–700 mm., and may have been immature fish. With specimens more than 700 mm. long prediction was nearly 100 per cent correct.

To our knowledge, these are the first recorded sexual colour differences in the Carangidae.

F. H. Talbot
F. Williams

East African Marine Fisheries
Research Organization,
Zanzibar.
Aug. 2.

Low Vitamin B_{12} Concentrations in Serum in Fish Tapeworm Anæmia

Various communications have been published on the microbiological vitamin B_{12} activity in the sera from both healthy persons and patients suffering from various diseases. The concentration of vitamin B_{12} varies fairly considerably in normal people. The lower limit is 70–100 μμgm. and the upper 420–900 μμgm. vitamin B_{12}/ml. of serum, depending on the microbiological method employed. Very low values, usually less than 50 μμgm./ml., have been found in pernicious anæmia[1].

Megaloblastic anæmia in fish tapeworm (*Diphyllobothrium latum*) carriers shows a similar hæmatological picture to that of genuine pernicious anæmia. The essential factor in the origination of this anæmia would seem to be vitamin B_{12} deficiency caused by fish tapeworm which deprives the host organism of vitamin B_{12} [2]. However, there is still a lack of data on the serum vitamin B_{12} concentration in this disease. We therefore determined the microbiological activity in the serum of eight patients with fish tapeworm anæmia. Twenty convalescents who had been treated for different diseases were examined as controls.

Table 1. Microbiological B_{12}-Vitamin Activity in Sera from Eight Patients with Fish Tapeworm Anæmia and from Twenty Controls

Diagnosis	Sex	Age	Vitamin B_{12} (μμgm./ml.)
Anæmia perniciosa diphyllobothrica	♀	38	< 50
,, ,, ,,	♀	17	< 50
,, ,, ,,	♀	14	< 50
,, ,, ,,	♀	11	< 50
,, ,, ,,	♀	64	< 50
,, ,, ,,	♂	58	< 50
,, ,, ,,	♂	63	65
,, ,, ,,	♀	84	< 50
Hypertensio arterialis	♂	59	605
Cholecystitis	♂	70	428
Hernia inguinalis	♂	61	720
Anæmia perniciosa diphyllobothrica in remission induced by worm cure	♂	17	361
Apoplexia cerebri	♂	63	733
Cardiosclerosis	♀	65	320
Anæmia hypochromica	♀	63	238
Ulcus ventriculi	♂	36	583
Anæmia perniciosa in remission induced by liver extract	♂	56	420
Polycythæmia vera	♂	37	424
Pneumonia lobaris	♂	57	940
Nephritis chronica	♂	42	644
Thyreotoxicosis	♀	71	360
Cardiosclerosis	♀	62	200
Cardiosclerosis	♂	69	180
Hernia diaphragmatica	♂	69	370
Nihil	♂	23	601
Cholecystopathia	♂	52	786
Arteriosclerosis universalis	♂	76	444
Diabetes mellitus	♂	57	964

Serum vitamin B_{12} activity was determined with *Lactobacillus leichmannii* 313 (*ATCC* 7830). The method employed was the same as that described in Appendix No. 1, 1955, of the Swedish Pharmacopeia. Values less than 50 μμgm./ml. cannot be measured with sufficient accuracy with this method. Table 1 summarizes the results.

It will be seen that there is a pronounced difference in the serum vitamin B_{12} activity of patients with fish tapeworm anæmia and that of the control group. Seven out of eight anæmia patients gave concentrations less than 50 μμgm./ml. A somewhat higher value, 65 μμgm. vitamin B_{12} per ml. of serum, was found in this group in one case only. The control group displayed great variations ranging from 180 to 964 μμgm. vitamin B_{12} per ml., the average being 561 μμgm. There was no overlapping between the two groups.

To obtain the variations and the mean value of the vitamin B_{12} concentrations in the serum of fish tapeworm anæmia patients requires both more comprehensive material and a more accurate method. However, this introductory investigation shows that the vitamin B_{12} serum concentrations in fish tapeworm anæmia are of the same range as those in genuine pernicious anæmia. This supports the view concerning vitamin B_{12} deficiency in *D. latum* carriers with anæmia.

WOLMAR NYBERG

IV Medical Clinic,
University of Helsinki.

GUSTAF ÖSTLING

Pharmacological Laboratory,
Medica, Ltd.,
Helsinki.
June 28.

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Stem Canker (*Macrophomina phaseoli*) of Cotton Seedlings in the Sudan Gezira

IN some seasons cotton seedlings (*Gossypium barbadense* L.) in the irrigated Gezira area of the Sudan suffer considerable damage from stem canker caused by the fungus *Macrophomina phaseoli* (Maubl.) Ashby, also known as *Rhizoctonia bataticola* (mycelium) and *Sclerotium bataticola* (sclerotia).

First symptoms are the appearance of circular red spots up to about 5–6 mm. in diameter on the cotyledons of seedlings two or three weeks after emergence from the soil. Under favourable climatic conditions, notably high humidity, these spots spread and extend down the cotyledonary stalk to produce a conspicuous reddish-purple lesion at the cotyledonary node. These lesions become brown, dry and fibrous as dissolution of the parenchymatous cortical tissue of the young stem proceeds and eventually small black sclerotia develop. In severe cases the stem is completely girdled at the cotyledonary node, at which point affected plants tend to break (especially if handled), and thereafter die or suffer a severe check to growth. In warm dry weather cankered plants often recover and the disease dries out without causing much damage.

In the 1954–55 season, one of above-average post-sowing rainfall, stem canker was very prevalent in the central and southern Gezira and must have imposed a considerable check on early growth of the crop—a warning that this disease might become a major problem were earlier sowing of cotton introduced. With such earlier sowing the young crop would experience much heavier post-sowing rain than with present sowing in mid-August, by which date about two-thirds of the season's rain has normally fallen. Thus at the Gezira Research Farm in 1954 stem canker was severe and post-sowing rainfall was much heavier than usual—about 200 mm. as compared with long-term average of about 120 mm.

Although field observations strongly suggest that stem canker is favoured by excessively wet conditions in which the seedlings are exposed to prolonged water-logging, the method of infection is obscure. Attempts to produce the cotyledonary stage of the disease by spraying cultures of the pathogen and by other methods have so far failed, but characteristic stem lesions (from which the fungus was afterwards recovered) resulted from needle inoculation of the green cotyledonary node.

Pycnidia of *M. phaseoli* have not been observed on cotton in the Sudan and it is thought that seasonal infection originates from the soil, wherein the fungus survives the hot dry season in the form of small resistant sclerotia. Supporting this theory is the observation that soil fumigation with chloropicrin tended to increase stem canker incidence at the Gezira Research Farm in 1954–55. Plots fumigated with chloropicrin three to four weeks before sowing showed 24 per cent cankered seedlings (10 gallons/acre), 32 per cent (20 gallons/acre) and 45 per cent (40 gallons/acre) as compared with 24 per cent in unfumigated plots. Plots fumigated with 15 per cent methyl bromide showed 22·5 per cent (20 gallons/acre) and 23·5 per cent (40 gallons/acre), while 0·8 per cent formaldehyde drench using about 160 gallons of commercial formalin per acre gave 23·5 per cent cankered seedlings. The initial damage due to stem canker in the chloropicrin-treated plots was more than counterbalanced by the beneficial effects of fumigation, these plots producing more vigorous plants which finally yielded 32–48 per cent more seed cotton than the unfumigated plots, as compared with yield increases of 8–15 per cent for methyl bromide and 5 per cent for formalin. It is possible that the resistant sclerotia of *M. phaseoli* were able to withstand chloropicrin fumigation whereas soil micro-organisms lacking such resistant propagules were destroyed. Under the resultant conditions of reduced competition *M. phaseoli* flourished and incidence of stem canker increased, but this was not the case in fumigation with methyl bromide and formaldehyde.

S. A. J. TARR

Botany and Plant Pathology Section,
The Gezira Research Farm,
Wad Medani, Sudan.
July 28.

Relevance of Palæomagnetic Studies of Jurassic Rocks to Continental Drift

THE early palæomagnetic studies have largely been confined to the northern hemisphere, where wide sampling of the geological column in Great Britain and North America has done much to establish the reality of polar wandering. Runcorn[1] has also suggested, on the basis of a comparison of the British and American results, that a westward drift of some 24° would account for the systematic difference he has found in the results.

Table 1

Region	Rocks sampled	Declination	Inclination	λ	K	N
N. Yorks*	Middle Lias —Lower Corallian. Arenaceous sediments	N. 3·4° E.	+66·9°	2·6°	87·5	36
Arizona	Kayenta Fm. (Lr. Jur.)	N. 6·9° W.	+43·5°	9·6°	50	6
North and South Rhodesia	Basalt lavas of Victoria Falls and Bulawayo	N. 30° W.	−40·3°	4·6°	18·7	44
Tasmania	Intrusive dolerite sills	N. 35° W.	−85°	—	—	—

* Full details to be published.

The critical test of whether continental drift has occurred or not obviously lies in a study of the palæomagnetism of rocks of the same age in different continents. In this context the Jurassic period is of great importance, and it is now possible to assemble data from four continents as in Table 1 with the relevant statistics[2].

Although the arenaceous sediments of the British Jurassic are largely unsuitable for palæomagnetic work, being either too weak for measurement or unstable, there are sufficient which appear to be stable to give the results tabulated. Runcorn's rocks from Arizona fall in the same category, and his results, which are based on a few specimens, must be regarded with caution.

The Rhodesian basalt lavas were collected from the Bulawayo area and from the Victoria Falls, where fresh material was obtained from the second gorge with the aid of Dr. G. Bond. The basalts following above the Triassic Forest Sandstone are generally considered of lower Jurassic age. The position of the pole in the northern hemisphere (lying in Hudson Bay) is in latitude 61° N., longitude 76° W. Irving[3] carried out an extensive study of the intrusive dolerite sills of Tasmania. These sills, while certainly of Mesozoic age, have not been proved conclusively to be of Jurassic age. The ancient pole position, according to Irving, lay in latitude 50° N., longitude 23° W.

Thus it is clear that, while Britain in Jurassic times must be regarded as having approximately the same position as at present relative to the pole (the present pole lying within the circle of confidence of the Jurassic results), and the movement of America is not significant, it is equally clear that this is not the case in the southern hemisphere. The Rhodesian lavas indicate a movement of about 2,000 miles, and the Tasmanian results a movement of about 2,800 miles.

The inevitable conclusion is that continental drift must be accepted if the assumption of the coincidence of the axial dipole field with the rotational axis is accepted[4]. More exact dating of the time of drift and the relative positions of the continental blocks must depend on the more detailed work at present in hand in Great Britain, South Africa and Australia.

A. E. M. Nairn

Department of Physics,
King's College,
Newcastle upon Tyne.
July 3.

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A Statistical Information Theory of Visual Thresholds

In their recent letter on this subject Gregory and Cane[1] state that "perhaps other threshold and summation phenomena may be described in terms of statistical information available in neural information channels". A survey of available data on the relationship between the Weber–Fechner fraction $\Delta I/I$ and stimulus area A certainly supports this contention[2].

Gregory and Cane make the assumption that the number of independent observations n is proportional to the stimulus area A. Admittedly this is the simplest assumption; but there would seem to be good reasons for believing that the number of independent observations would more closely approximate the number of nerve fibres, f, operating in the area A, and f is certainly not proportional to A except perhaps for a limited range of areas in the fovea. If f is the correct estimate of the number of independent observations, $\Delta I/I$ should be proportional to $1/\sqrt{f}$. Using data on the variation of visual acuity across the retina to provide an estimate of f, $\Delta I/I$ is in fact proportional to $1/\sqrt{f}$ to a good approximation, over the wide range of stimulus areas from 10′ diameter to 40° diameter. There is some tendency for $\Delta I/I$ to be larger than predicted at very small field sizes, where eye-movements are probably a complicating factor, and at very large field sizes, where there is probably mental difficulty in utilizing simultaneously all the information supplied. If $\Delta I/I$ is plotted against $1/\sqrt{A}$ the results for field sizes up to about 2° are similar; but those for larger field sizes are markedly worse. Thus, for a field size of 36°, using $1/\sqrt{f}$ the predicted value of $\Delta I/I$ is about half the actual value, but using $1/\sqrt{A}$ the predicted value is about one-ninth of the actual value.

This type of statistical approach is very useful in tackling visual problems of this nature, and if certain assumptions are made it can lead to far-reaching conclusions. For example, if it is assumed that

$$N = f_1(c) \cdot f_2(I)$$

where N is the magnitude of the physiological response evoked by a stimulus of intensity I, and c is a measure of the state of adaptation, f_1 and f_2 being any functions, then by arguments given in the paper cited

$$N = N_0 + f_1(c)I^{r/k}$$

where N_0 is a constant, and r/k is the ratio of $\Delta N/N$ to $\Delta I/I$, $\Delta N/N$ being the physiological equivalent of the Weber–Fechner fraction. The above relationship implies a linearity between $\log (N - N_0)$ and $\log I$, and electrophysiological studies show that this is approximately true if N is the number of nerve impulses per second per nerve fibre.

I am grateful to Gregory and Cane for having directed my attention (in a private communication) to a slight error in the mathematics of my paper[2]; the conclusions of the paper are unaffected, but the matter will be discussed in a short note, which I hope to publish as a correction to the original paper.

R. W. G. Hunt

Research Laboratories,
Kodak Limited, Wealdstone, Harrow,
Middlesex. July 20.

[1] Gregory, R. L., and Cane, Violet, *Nature*, **176**, 1272 (1955).
[2] Hunt, R. W. G., *J. Photo. Sci.*, **1**, 149 (1953).

Simultaneous Occurrence of 'Dawn Chorus' at Places 600 km. Apart

We have been observing whistlers and other naturally occurring audio-frequency noise at Wellington and Dunedin, New Zealand, since July 1955. The geomagnetic latitudes of these stations are 45° S. and 50° S. respectively, the distance apart being 600 km. approximately along a geomagnetic meridian. Certain of the whistler observations have already been described[1]; this communication deals with the simultaneous occurrence at the two stations of the phenomenon known as 'dawn chorus', which has been described by Storey[2] as consisting of a multitude of rising whistles, and sounding like a rookery heard from a distance. Dawn chorus is heard most frequently in the early hours of the morning and is correlated with magnetic activity; however, at present there exists no theory relating to its production or propagation.

Normally, during a period of dawn chorus activity, the rising whistles or tones occur at a rate of one rising tone every few seconds. However, occasionally a 'burst' of dawn chorus occurs, during which the rate exhibits a sudden and spectacular increase; thus a burst consists of a group of rising tones which arrive in abnormally rapid succession. Often the tones overlap, the high-frequency components of one tone arriving at the same time as the low-frequency components of the next tone.

Simultaneous recordings on magnetic tape have been made at the above stations on a schedule of 4-min. recording every 3 hr., usually on two consecutive days per week. Of the 273 simultaneous schedules recorded to date, dawn chorus has been heard at Wellington during 106, and at Dunedin during 64 schedules. In 56 cases dawn chorus has been heard at both stations during the same schedule.

An exceptionally clear display of dawn chorus was registered during the early morning hours of March 25, 1956. In particular, the schedule commencing at 1740 G.M.T. contained fine examples of bursts. The spectrograms of a portion of this schedule which contained 5 bursts are shown in superimposed form in Fig. 1. The rectangles of finite area are so drawn for clarity of display. Each one represents a line joining the two points marking the commencement (or leading edge) and the finish (or trailing edge) of a particular frequency component in the burst. Thus the leading edge can in general be identified with the first rising tone, and the trailing edge with the last rising tone, in the burst. It is seen that the bursts occur simultaneously at the two stations to within close time limits. Accurate timing was achieved by

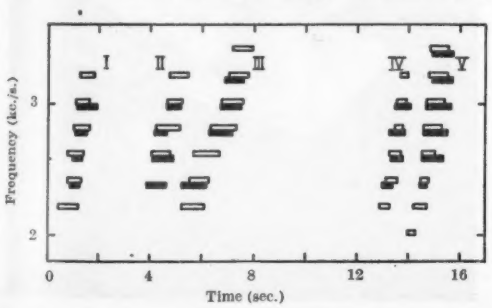

Fig. 1. Spectrograms of dawn chorus bursts. White rectangles: Wellington; black rectangles, Dunedin

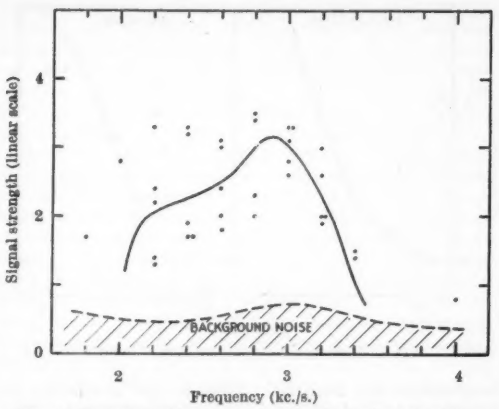

Fig. 2. Variation with frequency of the signal strength of dawn chorus bursts at Wellington

making all measurements with reference to the times of occurrence of loud 'bonks'[3]. By consideration of the possible propagation paths involved, it is found that these 'bonks' are coincident at the two stations to within 2 m.sec. The average difference in time of occurrence at Wellington and Dunedin for the bursts in Fig. 1, for all frequencies and including both leading and trailing edges, is less than 0·01 sec., while one-half of the individual time-differences is less than 0·1 sec. in magnitude. The leading edges tend to be more closely coincident than the trailing edges, one-half of the individual time-differences for the leading edges being less than 0·06 sec. This is probably because the first rising tone in a burst tends to be stronger than the last one, the timing of which is therefore more likely to be affected by background noise.

A supplementary set of spectrograms of these bursts taken at 6·6 times the normal speed did not reveal significantly closer coincidences. It is inferred, therefore, that the finite time-differences are not due to the experimental technique; but that at least the majority of these differences are real, and represent slight variations in the characteristics of the phenomenon at places separated by 600 km.

A noticeable feature of these bursts is that appreciable energy is received over a rather limited frequency range of less than an octave. Fig. 2 shows a mass plot of peak signal strength against frequency for all five bursts of Fig. 1, together with the average curve, showing a maximum of received energy just below 3 kc./sec.

No spectrograms have yet been made of an isolated rising tone. However, the detailed character of the rising tones in these bursts can be seen from Fig. 3, which shows on an expanded time-scale the shape of the leading edge of burst V of Fig. 1. The shape is also typical of both leading and trailing edges of bursts I and IV. After a relatively slow start, the pitch increases almost linearly from 2·6 to 3·4 kc./sec. This linear portion has an average slope of 2·0 kc./sec.^{2}, varying in actual cases between 1·5 and 3·0 kc./sec.^{2}. The other bursts shown in Fig. 1 (bursts II and III) do not appear at first sight to conform to the same pattern. However, aural observation shows that these latter bursts consist of a series of rising tones of even more limited frequency-range, the earlier tones in the burst containing only the lower frequencies, while in the later stages only the higher

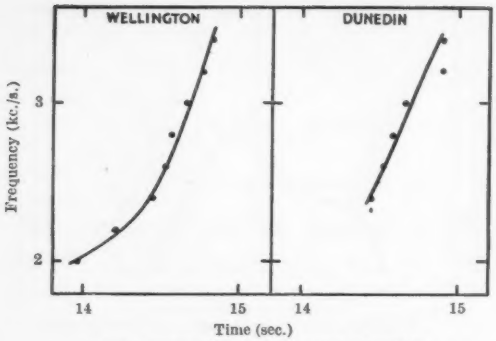

Fig. 3. Spectrograms of leading edge of burst V

frequencies are audible. This is also a feature of bursts of long duration heard at other times. The shapes of the leading edges for the lower frequencies, and of the trailing edges for the higher frequencies, generally match the respective portions of Fig. 3. Thus it is most likely that there is no basic difference in the characteristics of the rising tones throughout the schedule, apart from restriction of the frequency range in some cases.

A full discussion of these results and other data leading to a theory of dawn chorus will be published elsewhere. We are grateful to Dr. M. G. Morgan, of Dartmouth College, New Hampshire, U.S.A., for his encouragement and assistance in providing equipment for this project.

G. McK. Allcock
Dominion Physical Laboratory,
Lower Hutt, New Zealand.
L. H. Martin
New Zealand Broadcasting Service,
Dunedin, New Zealand.
June 22.

[1] Morgan, M. G., and Allcock, G. McK., *Nature*, **177**, 30 (1956).
[2] Storey, L. R. O., *Phil. Trans. Roy. Soc.*, A, **246**, 113 (1953).
[3] Morgan, M. G., and Dinger, H. E., *Nature*, **177**, 29 (1956).

Beta-Gauge for Hair Measurements

The quantitative measurement of hair is an important factor in studies of heat exchange between animal and environment. Methods currently employed consist in counting the number of hairs per unit area, measuring the mean hair length, and determining the weight of hair per unit area. In measurements of hair number or hair weight per unit area a major error arises from the difficulty of measuring precisely an area on the mobile, elastic, non-planar skin of an animal. Any method requiring the removal of the hair for measurement changes the heat-transfer characteristics of the area, and repeat measurements cannot be made on the same area. An absorption-type beta-ray gauge would appear to offer a solution to the problem of measurement of the mass of hair per unit area. It would be a rapid, non-destructive, and reasonably accurate direct measurement of the mass of hair per unit area at the point of measurement.

A transmission-type beta-gauge for *in vivo* measurement of hair areal density must consist of a radiation source that may be placed on the skin of the animal with minimum disturbance to the hair, and a sensitive receptor a fixed distance from the source. In the present design, the beta-emitter was mounted in a 0·035-in. diameter depression in the side of a 0·094-in. diameter stainless steel rod attached by a light aluminium frame to a Geiger tube (Fig. 1). The radioisotopes used (promethium-147, thallium-204) were mounted as components of a fused enamel[1]. This method of mounting allows the maximum energy of the beta-emitter to be utilized because no absorbing material is introduced between the radionuclide and the detector. These two isotopes permit measurement of a wide range of hair densities. Promethium-147 becomes unusable at about 15 mgm./cm.^{2} and thallium-204 at about 80 mgm./cm.^{2}. The thickness of the stainless steel around the source (0·04 in.) is sufficient to provide saturation back-scattering at all beta energies used and also shields the animal from the source. This was demonstrated to prevent variations in count-rate due to variations in the proximity of bone to the surface of the animal.

A mica-window Geiger tube was chosen as the detecting element so that a minimum amount of radioactivity could be used in the gauge, since the necessity of having a large open volume around the source precludes the use of radiation shielding. The particular Geiger tube used (Anton Electronic Company No. 210-*H*) is supplied with the distal end threaded and thus becomes an integral part of the structure of the gauge.

The hair measurement beta-gauge was calibrated with aluminium absorbers. Measurements of hair density were made with this beta-gauge and compared with the density obtained by weighing the hair clipped from a measured area. Examples of these measurements are shown in Fig. 2 with the aluminium calibration curve for the gauge using thallium-204.

Fig. 1. Using the hair measurement beta-gauge. The thin probe is slid along the skin under the hair and the decreased count-rate noted. This is compared with a standard curve

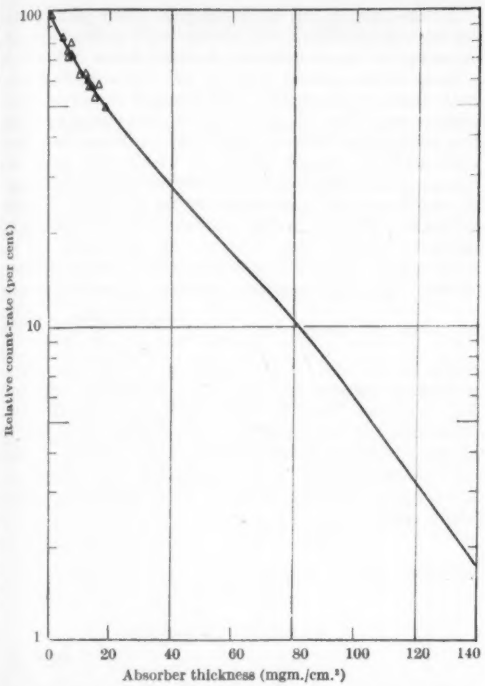

Fig. 2. Standard curve for the hair measurement beta-gauge using thallium-204. The points shown are for *in vivo* measurement of hair density in cattle

The precision of measurements obtained with the hair measurement beta-gauge was determined by repeated measurements on twelve cows. Two hundred and ninety comparisons indicate a probable error of $\pm 4{\cdot}4$ per cent when the gauge was used with an integrating rate meter the time constant of which was equivalent to a standard error of ± 2 per cent.

Details of construction and application of the gauge will be reported elsewhere. This investigation was supported in part by the Division of Biology and Medicine of the U.S. Atomic Energy Commission.

CLIFTON BLINCOE*

Department of Dairy Husbandry,
Missouri Agricultural Experiment Station,
Columbia, Missouri.

* Present address: Department of Agricultural Chemistry, University of Nevada, Reno, Nevada.

[1] Blincoe, C., *Nucleonics*, **14**, No. 8, 82 (1956).

Effect of Alloying on the Energy-Levels of Inner Electronic Shells

WHEN two elements such as copper and zinc are alloyed together there is a change in the distribution of the valence electrons; charge is transferred from zinc atoms to copper atoms. Thus Mott[1] has estimated that $\sim 0{\cdot}1$ electron is transferred from zinc to copper in β-brass. Again, the calculated charge shift in a concentrated copper–zinc alloy is $\sim 0{\cdot}5\,c$ electron transferred from each zinc cell to a copper cell, where c is the concentration of copper in the alloy[2]. In the latter case there is reasonably good agreement between the change in width of the valence electron energy bands for zinc and copper as observed experimentally and as calculated assuming that the energy-levels of the valence electrons in the alloy can be separated into two free-electron bands, one for zinc and one for copper, with a common Fermi energy.

However, on these simple views of alloying[2] one might expect that when, for example, electrons are transferred from zinc to copper atomic polyhedra in brass, there will be a shift towards higher energies of the whole energy band for the valence electrons of copper, plus a broadening of the band. Conversely, the zinc valence electron band may be expected to shift to lower energies coupled with a decrease in band width. One expects, then, both the upper and lower energy limits of the valence bands to change, the upper more than the lower, both bands having a common absolute upper limit—the Fermi energy.

But experimental X-ray spectroscopic measurements of dipole transitions from the valence bands to the atomic K-levels[3] indicate that although there are changes in intensity on the high-energy sides of the valence energy bands of copper and zinc, nevertheless the wave-length (and hence apparent energy) of the emission edge stays constant for both zinc and copper, to within experimental error. The energy band of copper broadens on alloying with zinc and hence the long wave-length (low-energy) emission of copper moves to longer wave-lengths and lower energies. Conversely, the long wave-length side of the zinc line moves to higher energies while, again, the high-energy emission edge is observed to stay constant. Similar behaviour is observed in other alloy systems which have been studied, although there are exceptions. Thus in nickel–zinc alloys a shift in the emission edge of the zinc band to lower energies is observed[4].

Experimental evidence thus largely appears to contradict the expected electronic behaviour on alloying. The following simple explanation is put forward to remove this contradiction. This is offered as an alternative to the proposal put forward by Friedel[5] to account for these observations.

Consider, once again, an alloy of copper and zinc. Charge transfer on alloying results in an electron, with a wave-function which will be a modified $4s$ function, moving away from a zinc polyhedron to a neighbouring copper cell. Now the amplitude of an S-state wave-function is large at the nucleus of the atom, and for a hydrogen-like $4s$ function the amount of electronic charge contained within the volume defined by the Bohr radius of the K-shell electrons is:

$$\varepsilon \sim \left(\frac{Z}{a_0}\right)^3 \left(\frac{a_0}{Z}\right)^3 \frac{1}{64\pi} \sim \frac{1}{200}$$

for one $4s$-electron transferred from a zinc into a copper cell.

The energy change in the K-level of copper will thus be $\sim +2.Z_{Cu}\,\varepsilon\,13{\cdot}53\,n$ volts, where Z_{Cu} is the effective nuclear charge, ε is the additional very small screening introduced by one extra $4s$ electron introduced into the copper cell and n is the fractional charge shift. Thus if $n = \frac{1}{4}$ the energy change of the K-level is ~ 1 volt. The K-level of copper will be increased by ~ 1 volt and that of zinc will decrease by ~ 1 volt.

A more refined calculation using first-order perturbation theory has been carried out, and this predicts an energy increase for a $1s$-state electron in

copper to be $\sim 2{\cdot}6\,n$ volts, where n is the fraction of charge in a copper polyhedron, transferred from a zinc cell. The perturbing potential used was that due to the charge density of a 4*s* hydrogen-like wave function, and the wave function of the hydrogen-like 1*s*-state was assumed for the K-level. The maximum change in width of the energy band for copper in brass, that is, the difference in widths of the band in pure copper and that of very dilute copper in zinc solution, is $\sim 0{\cdot}9$ eV. Assuming that the electrons around the zinc and copper atoms have their energies distributed over a free electron spectrum based on respective ground-state energies[2], this change in width corresponds to an electron transfer of $\sim 0{\cdot}73$ electron into a copper cell for very dilute copper in zinc. The associated energy change of the copper K-level is thus $\sim 1{\cdot}9$ eV. Now the Fermi energy of the copper band will have its absolute energy raised by more than the increased width of the band, since it is estimated that the ground-state energy is itself raised by $\sim 1{\cdot}5$ times the increase in width of the Fermi band[3]. The Fermi energy will thus be raised in energy by an amount $\sim 2{\cdot}35$ eV., so that both it and the K-level increase in absolute energy (relative to an electron at rest in free space) by the same order over the whole range of alloys. In this case the emission wave-lengths for transitions from the top of the Fermi band to the K-shell will stay nearly constant with alloying, and the broadening of the Fermi band will appear as an increase in long wave-length transitions. The calculations are not accurate enough to predict whether the increase in absolute energies of the K-level and the top of the Fermi band will be the same to within experimental error; but the concept that this does occur, as discussed above, leads to a straightforward removal of a contradiction to the simple view of electron behaviour on alloying.

These arguments hold both for the emission and absorption spectra in alloys. In the former case, as Friedel has already discussed[5], the positive hole in the K-shell will be screened by a redistribution of the valence electrons in such a way that the Fermi-level remains constant. In this way Friedel accounts for the emission and absorption edges occurring at the same wave-length. Nevertheless, the effect described in this communication will still hold good whatever the details of the valence electron distribution.

I wish to thank Mr. A. D. Le Claire for providing the initial stimulus, and to thank him, Mr. J. Hubbard and Dr. H. M. Finniston for helpful discussions.

J. H. O. Varley

Metallurgy Division,
Atomic Energy Research Establishment,
Harwell.
July 16.

[1] Mott, N. F., *Proc. Phys. Soc.*, **49**, 258 (1937).
[2] Varley, J. H. O., *Phil. Mag.*, **45**, 887 (1954).
[3] Bearden, J. A., and Friedman, H., *Phys. Rev.*, **58**, 387 (1940).
[4] Bearden, J. A., and Beerman, W. W., *Phys. Rev.*, **51**, 396 (1940).
[5] Friedel, J., *Phil. Mag.*, **43**, 153 (1952).

Effect of Pressure on the Dielectric Constant of Vitreous Silica

Since there are, to our knowledge, no reported observations of the effect of pressure on the dielectric constant of any solid, the data that we have obtained on this effect in vitreous silica may be of some interest, even though the precision of our results is low, and vitreous silica is far from being a typical solid.

In the course of calibrating a silica piezometer, we have determined the change with pressure in the capacity of the condenser formed by a silica tube with a silver coating fired on the outside, and filled with mercury extending well beyond the ends of the silver coat. This change is about ten times less than the change in the stray capacity between the silver coat and the metal shield in which the tube was mounted, and was determined by taking the difference of two runs, one with mercury in the tube and one without. The imperfect reproducibility of the stray capacity change has limited the precision of the final results to about $\pm$ 5 per cent of the maximum effect. The relative change in the dielectric constant of silica is given by $\frac{\Delta\varepsilon}{\varepsilon} = \frac{\Delta c}{c} - \frac{\Delta l}{l}$; for this computation we have used weighted means of published figures for the compressibility of silica. Fig. 1 shows $\Delta\varepsilon/\varepsilon$ to 4,000 kgm./cm.^{2}, at the temperatures 20° and 138° C. The limits of error are shown by vertical lines through the plotted points. All measurements were made at the frequency 2,500 c.p.s., with a maximum field strength of about 100 V./cm.

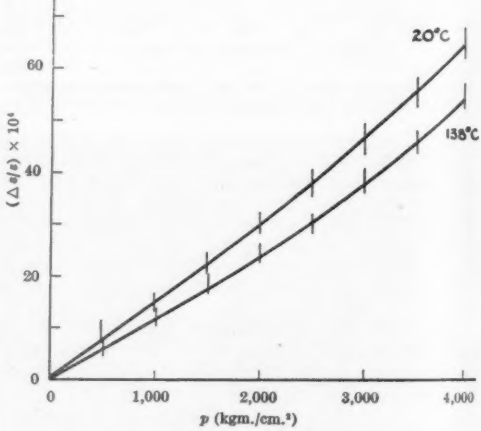

Fig. 1. $\Delta\varepsilon/\varepsilon$ vs. p for vitreous SiO_2

Within our limits of error, the molecular polarization $[P]$ of silica, proportional to $\frac{\varepsilon - 1}{\varepsilon + 2} \cdot \frac{1}{d}$, appears to decrease linearly under pressure, with a slope independent of temperature. The coefficient $\frac{1}{[P]} \cdot \frac{\delta[P]}{\delta p}$ has the value $-1{\cdot}6 \times 10^{-6}$ per kgm./cm.^{2}, about 3–10 times less than the values found for most of the non-polar liquids that have been studied under pressure.

We wish to thank Mr. Arthur K. Doolittle and the Carbon and Carbide Chemicals Co. for support of this work.

John Reitzel

Arthur D. Little, Inc.,
Cambridge, Mass.
June 15.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 29

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. E. H. Brown: "Physique of Wales".

Monday, October 29—Friday, November 2

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND MEASUREMENT SECTIONS (at Savoy Place, London, W.C.2).—Convention on "Ferrites".

Tuesday, October 30

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. H. Kalmus: "Behaviour and Heredity"*.

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, Westminster, London, S.W.1), at 5.30 p.m.—Symposium on "Side Spillways".

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Mr. J. R. Shakeshaft: "Radio Astronomy"*.

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. E. C. Amoroso: "Endocrinology and Pregnancy"*. Sixth of fourteen lectures on "The Scientific Basis of Medicine". Further lectures on November 1, 6, 8, 15, 20, 22, 27 and 29.)

SOCIETY OF INSTRUMENT TECHNOLOGY (joint meeting with the CONTROL SECTION, at Manson House, Portland Place, London, W.1), at 7 p.m.—Mr. D. S. Townend: "Control Engineering and the Automatic Process Plant".

ROYAL AERONAUTICAL SOCIETY, GRADUATES' AND STUDENTS' SECTION (at 4 Hamilton Place, London, W.1), at 7.30 p.m.—Mr. E. P. Hawthorne: "Nuclear Power for Aircraft".

Wednesday, October 31

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. W. S. Pitcher and Dr. R. C. Sinha: "The Petrochemistry of the Ardara Aureole"; Mr. Bryan P. Ruxton: "Notes on Some Important Contacts in Hong Kong".

UNIVERSITY COLLEGE, LONDON (in the Gustave Tuck Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. M. Dunand: "Néolithique et Enéolithique à Byblos". (First of three Special University Lectures in Archæology (to be delivered in French). Further lectures on November 1 and 2.)*

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6 p.m.—Annual General Meeting. 7.15 p.m.—Mr. George A. Marriott—Presidential Address.

INSTITUTION OF MECHANICAL ENGINEERS, ENGINEERING PRODUCTION GROUP and EDUCATION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "Selection and Training of Engineering Designers".

Thursday, November 1

CHEMICAL SOCIETY (in the Chemistry Department, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Symposium on "Newer Interpretations of Reactions and Structure in Carbohydrate Chemistry".

LINNEAN SOCIETY OF LONDON (joint meeting with the SYSTEMATICS ASSOCIATION at Burlington House, Piccadilly, London, W.1), at 4 p.m.—Discussion on "The Inheritance of Acquired Characters".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Dr. E. F. Gale, F.R.S.: "The Biochemical Organization of the Bacterial Cell".

MINERALOGICAL SOCIETY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—General Meeting.

UNIVERSITY OF LONDON (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 5 p.m.—Prof. Georges Portmann (Bordeaux): "The Physiology of Phonation"* (Semon Lecture).

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, Westminster, London, S.W.1), at 5.30 p.m.—Prof. L. Dudley Stamp: "Conservation of Land". (Third of a series of six lectures on "The Conservation of Natural Resources".)

INSTITUTE OF METALS, LONDON LOCAL SECTION (at the Royal School of Mines, South Kensington, London, S.W.7), at 7 p.m.—Prof. F. C. Thompson: "Primitive Metallurgy".

ROYAL INSTITUTE OF CHEMISTRY (at the Technical College, Fassett Road, Kingston), at 7 p.m.—Dr. Tudor S. G. Jones: "Chromatography".

Friday, November 2

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in Room 425, Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 6 p.m.—Mr. L. J. Holman: "Some Differences between Potential Officers from North and South England".

INSTITUTION OF MECHANICAL ENGINEERS, INTERNAL COMBUSTION ENGINE GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. P. F. Ashwood: "A Review of the Performance of Exhaust Systems for Gas-Turbine Aero Engines".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. J. R. Gass: "Automation"*. (Fourth of ten University Extension Lectures on "Technology and Industry". Further lectures on November 9, 16, 23, 30, December 7 and 14.)

SOCIETY OF COSMETIC CHEMISTS OF GREAT BRITAIN (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7.30 p.m.—Mr. T. W. Watson: "Silicones in the Cosmetic Industry".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. Tom M. Harris, F.R.S.: "The Investigation of a Fossil Plant".

Saturday, November 3

BRITISH INTERPLANETARY SOCIETY (in the York Hall, Caxton Hall, Caxton Street, London, S.W.1), at 6 p.m.—Dr. R. M. Goody: "The Atmosphere of Mars".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANTS IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (October 31).

DEMONSTRATOR (graduate in metallurgy or chemistry) IN METALLURGY—The Registrar, Manchester College of Science and Technology, Manchester 1 (October 31).

TECHNICIAN (A.I.M.L.T. or equivalent) IN THE CHEMICAL PATHOLOGICAL LABORATORY—The Group Secretary, North Middlesex Hospital, Edmonton, London, N.18 (November 3).

DIVISIONAL PHYSICIST (with a good honours degree in physics and preferably some experience in industry), to organize and lead the Divisional Dust Suppression Team, collaborate with the areas in investigations on ventilation and illumination, and work to stimulate the adoption of scientific methods of control—The Staff Department (A.3), National Coal Board, Northern (N. and C.) Division, Whitely Road, Longbenton, Newcastle-upon-Tyne 12 (November 7).

BIOCHEMIST, Senior grade, to work under the Director of the Department of Clinical Biochemistry—The Administrator, Radcliffe Infirmary, Oxford (November 10).

LECTURER IN MATHEMATICS at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 10).

LECTURER IN THE DEPARTMENT OF BACTERIOLOGY—The Secretary, The University, Edinburgh (November 10).

RESEARCH STATISTICIAN (with a good knowledge of biometric techniques and a special interest in the design and analysis of experiments), to work under contract with Torry Research Station (D.S.I.R. Food Investigation Organization)—The Secretary, The University, Aberdeen (November 10).

CHEMIST (Research Officer) (with at least a university degree with first- or second-class honours, and preferably research experience in inorganic or physical chemistry) with the Australian Atomic Energy Commission, to undertake research into the effect of radiation on nuclear fuel materials and other reactor components, and to assist in a programme of nuclear fuel development—Officer-in-Charge, A.A.E.C. Research Establishment, Private Mail Bag, Sutherland, N.S.W., Australia (November 12).

PUBLIC ANALYST AND GOVERNMENT BACTERIOLOGIST in the Isle of Man—The Government Secretary, Government Office, Isle of Man (November 15).

RESEARCH ASSISTANT in Soviet Institutions—The Secretary of University Court, The University, Glasgow (November 15).

SENIOR LECTURER IN CHEMICAL ENGINEERING at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Cape Town, November 15).

CHAIR OF PHILOSOPHY in the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 16).

SOIL PHYSICIST (with a good second-class honours degree in chemistry and/or physics) to carry out physical and nutrient determinations of irrigated soils; an AGRONOMIST (with a university degree in agriculture or natural science or a diploma of an agricultural college of university status which has involved at least a three-year course of study, plus one year postgraduate or post-diploma training in agricultural science) to study and determine the agronomic and economic possibilities of both irrigated and unirrigated crops; and an IRRIGATION ENGINEER (with a good degree in agricultural engineering and specialized in land engineering) to be responsible for the preparation of fields, layout of field irrigation channels and the determination, in conjunction with the Soil Physicist and Agronomist of the times and amounts of irrigation—The Secretary for Recruitment, Gold Coast Civil Service, 13 Belgrave Square, London, S.W.1 (November 16).

RESEARCH ENGINEER or PHYSICIST (with a university honours degree in mechanical or electrical engineering, or in science with physics as the major subject, or equivalent qualifications, together with some research experience) IN THE SHEEP BIOLOGY LABORATORY, Division of Animal Health and Production, Commonwealth Scientific and Industrial Research Organization, Prospect, New South Wales, Australia, to collaborate with biologists in the research programme of the climate physiology group—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 205/108 (November 17).

RESEARCH OFFICER (with an honours degree in science or equivalent qualifications with physics or chemistry as major subjects, together

with some research experience) IN THE DIVISION OF INDUSTRIAL CHEMISTRY, Commonwealth Scientific and Industrial Research Organization, Fisherman's Bend, Melbourne, Victoria, Australia, to undertake a study of the nucleation and growth of crystals, in particular to study the growth of ice crystals from the vapour phase on such nucleating material as silver iodide—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 590/601 (November 17).

SENIOR LECTURER (preferably with experience of research in the solid state field) ON THE STAFF OF THE DEPARTMENT OF PHYSICS, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, November 19).

DIRECTOR OF THE INSTITUTE FOR SOCIAL RESEARCH, University of Natal, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, November 23).

BOSCH CHAIR OF HISTOLOGY AND EMBRYOLOGY in the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 26).

ASSOCIATE PROFESSOR IN MINING ENGINEERING at the New South Wales University of Technology, Sydney—The Agent General for New South Wales, 56 Strand, London, W.C.2 (Australia, November 30).

LECTURER (honours graduate in biochemistry or chemistry with postgraduate experience in biochemistry and preferably with an interest in comparative biochemistry) IN BIOCHEMISTRY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 30).

LECTURER IN AGRICULTURAL ZOOLOGY at Makerere College, University College of East Africa—The Secretary Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 30).

SENIOR LECTURER (preferably with primary interest and experience in fluid mechanics) IN MECHANICAL ENGINEERING at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 30).

ASSISTANT IN PHYSIOLOGY IN THE DEPARTMENT OF PHYSIOLOGY AND BIOCHEMISTRY—Joint Clerk to the University Court, Queen's College, Dundee (December 1).

COMMEMORATION FUND RESEARCH FELLOW (woman graduate of any university), for research in mathematics, natural sciences or an allied subject—The Secretary, Girton College, Cambridge (January 15).

ASSISTANT LECTURERS (2) IN PHYSICS—The Secretary, Royal College of Science and Technology, George Street, Glasgow.

BIOCHEMIST, Basic grade (graduate, preferably with experience in, and a knowledge of chromatographic methods), for research work in problems of metabolism in mental deficiency—The Physician Superintendent, St. Lawrence's Hospital, Caterham, Surrey.

ENTOMOLOGISTS (with a good honours degree in zoology and training in entomology) IN THE DEPARTMENT OF TSETSE CONTROL, Gold Coast Local Civil Service, to investigate various aspects of the bionomics and ecology of tsetse flies in relation to man and animals and to supervise control measures under the Director of Tsetse Control—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.77/13/01.

INDUSTRIAL CHEMIST (with an honours degree in chemistry or membership of the Institution of Chemical Engineers, and at least ten years experience as a chemist in industry since qualifying) IN THE DEPARTMENT OF HEAVY INDUSTRIES, Eastern Region, Nigeria, to advise on the design of a laboratory and subsequently direct its work, and to undertake research into local raw materials, organic and inorganic, and their potential utilization either alone or in combination with imported material—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.461/411/02.

LABORATORY TECHNOLOGIST (male or female, with A.I.M.L.T. or equivalent, a knowledge of biochemistry and forensic and anthropological experience) IN THE KENYA GOVERNMENT POLICE DEPARTMENT—The Crown Agents, 4 Millbank, London, S.W.1, quoting M.3/43685/NF.

LABORATORY TECHNOLOGIST (male, preferably single and preferably A.I.M.L.T., and experienced in laboratory techniques and animal handling) IN THE TANGANYIKA GOVERNMENT VETERINARY DEPARTMENT, for laboratory duties and field work on animal disease problems—The Crown Agents, 4 Millbank, London, S.W.1, quoting M.3/35063/NF.

LECTURER IN THE DEPARTMENT OF CHEMISTRY—The Principal, The Percival Whitley College of Further Education, Halifax.

PHYSICIST IN CHARGE AT THE NORTHERN IRELAND RADIOTHERAPY CENTRE—The Secretary, Northern Ireland Radiotherapy Centre, Purdysburn, Belfast.

PHYSICIST, Senior grade (with a knowledge of X-rays, radium and radioactive isotopes) IN THE RADIOTHERAPY DEPARTMENT, for duties concerning routine radiotherapy physics, and the applications of radioactive substances in other branches of medicine—The Secretary to the Board of Governors, Charing Cross Hospital, London, W.C.2.

PRINCIPAL/SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree in mathematics, and several years postgraduate research experience in applied mechanics), to provide general theoretical assistance to a group engaged on the development of nuclear reactors for military application (Ref. No. 1299/34); and a SCIENTIFIC OFFICER (with a first- or second-class honours degree in physics, mathematics or engineering, or equivalent qualifications), to carry out research and development work in the field of applied mechanics (Ref. No. A.1221/34)—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting appropriate Ref. No.

RESEARCH ASSISTANT (with either (*a*) a degree in chemistry or physics and an interest in the physical-chemistry of viruses and other biological macromolecules, or (*b*) appropriate laboratory experience) IN THE BIOPHYSICS DEPARTMENT—The Secretary, Research Institute (Animal Virus Diseases), Pirbright, Surrey.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Planning. Vol. 22, No. 401 (13 August, 1956): The Cricket Industry. Pp. 157–172. (London: Political and Economic Planning, 1956.) 2*s*. 6*d*. [23

Air Ministry: Meteorological Office. British Rainfall 1954: the Ninety-Fourth Annual Volume of the British Rainfall Organization (Report on the Distribution of Rain in Space and Time over Great Britain and Northern Ireland during the year 1954, as recorded by about 5,000 Observers.) Pp. iv+215. (London: H.M. Stationery Office, 1956.) 25*s*. net. [23

The International Journal of Applied Radiation and Isotopes. Vol. 1, Numbers 1/2 (July, 1956). Pp. 144. Subscription per volume: (a) £6 (U.S.A. 17 dollars); (b) for individual subscribers certifying that the journal is for their private use, £3 10*s*. (U.S.A. 9.80 dollars), including postage. (London and New York: Pergamon Press, 1956.) [23

Department of Scientific and Industrial Research: Road Research Laboratory. Road Note No. 21: Tests on the Efficiency of a Twin-Shaft Paddle Mixer with various Settings of the Paddle Tips. By W. L. Russell. Pp. 12. (London: H.M. Stationery Office, 1956.) 1*s*. 6*d*. net. [23

Freshwater Biological Association. Twenty-fourth Annual Report for the year ended 31st March 1956. Pp. 70. (Ambleside: Freshwater Biological Association, 1956.) 3*s*. [23

Institute of Seaweed Research. Annual Report for 1955 and review of the Institute's Activities, 1945–1955. Pp. 52. (Inveresk, Midlothian: Institute of Seaweed Research, 1956.) [23

Bulletin of the British Museum (Natural History). Zoology. Vol. 4, No. 2: The Evolution of Ratites. By Sir Gavin de Beer. Pp. 57–70+plates 5–9. 10*s*. Vol. 4, No. 3: Studies on the Trichiuroid Fishes. 3—a Preliminary Revision of the Family Trichiuridae. By Denys W. Tucker. Pp. 73–130+plate 10. 20*s*. (London: British Museum (Natural History), 1956.) [23

Other Countries

New Zealand Forest Service. Information Series, No. 19: Management of Woodlots. By W. H. Jolliffe. Pp. 20+8 plates. (Wellington: Government Printer, 1956.) [23

Indian Central Cotton Committee: Technological Laboratory. Technological Bulletin, Series A, No. 89: Technological Reports of Trade Varieties of Indian Cottons, 1955. By Dr. C. Nanjundayya. Pp. ii+88. (Bombay: Indian Central Cotton Committee, 1956.) Rs. 2. [23

The Isotope Index: First Complete Guide to the Isotopes. Vol. 1, No. 1 (June 1956). Pp. 64. (Indianapolis, Indiana: Scientific Equipment Corporation, 1956.) U.S.A. and Canada, 2 dollars; Foreign, 2.50 dollars. [23

New Zealand. Department of Scientific and Industrial Research: Geophysics Division. Amberley Observatory—Magnetic Results for 1954. Pp. iv+56. (Wellington: Government Printer, 1955.) [23

Proceedings of the First International Conference on the Use of Antibiotics in Agriculture, held under the auspices of the Agricultural Board and the Agricultural Research Institute, National Academy of Sciences—National Research Council, 19–21 October 1955. Pp. xx+278. (Publication 397.) (Washington, D.C.: National Academy of Sciences—National Research Council, 1956.) 2.50 dollars. [23

Federation of Nigeria. Annual Report of the Department of Agriculture (Central), for the year 1953–54, Part 1. Pp. 8. (Lagos: Government Printer, 1956.) 9*d*. net. [23

Federation of Nigeria. Annual Report of the Geological Survey Department for the year 1954–55. Pp. 14. (Lagos: Federal Government Printer, 1956.) 9*d*. net. [23

Canada. Department of Mines and Technical Surveys. Publications of the Dominion Observatory, Ottawa. Vol. 14, No. 16: Bibliography of Seismology, Items 8773–8947, July–December, 1954. By W. E. Smith. Pp. ii+339–360. (Ottawa: Queen's Printer, 1956.) 1 cents. [23

Durban Museum Novitates. Vol. 4, No. 16 (20th May, 1956): Some Records of South African Casaidinae (Col. Chrysomelidae). By S. Shaw. Pp. 257–272. 3*s*. net. Vol. 4, No. 17 (30th June, 1956): Miscellaneous Taxonomic Notes on African Birds. By P. A. Clancey. Pp. 273–29 (Durban: Durban Museum and Art Gallery, 1956.) [23

Publications de l'Observatoire de Genève. Série A: Astronomie, Chronométrie, Géophysique. Fascicule 52: Sur les Problèmes non Résols posés par l'Étude de la Marche des Chronomètres. Par P. Tiercy. Pp. ii+11. Fascicule 53: Remarques sur le Système Photométrique de H. L. Johnson et W. W. Morgan et sur la Photometrie des Six Couleurs de J. Stebbins et A. E. Chitford. Note par M. Golay. (Estratto delle Memorie della Societe Astronomica Italiana, Vol. 26–4 Pp. ii+9. Série M: Météorologie. Fascicule 30: Résumé Météorologique de l'Année 1955 pour Genève. Par Ernest Rod. Pp. 1 Résultas des Observations de Chronomètres en 1955. Pp. 10. (Genève: l'Observatoire, 1955 et 1956.) [23

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